INTERPERSONAL NETWORKS IN MULTITEAM SYSTEMS:

DIFFERENTIAL IMPACT OF LEVELS AND STATES

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INTERPERSONAL NETWORKS IN MULTITEAM SYSTEMS:

DIFFERENTIAL IMPACT OF LEVELS AND STATES

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SUMMARY

Multiteam systems (MTSs), defined as two or more interdependent teams working towards both proximal team goals and at least one shared goal, are prevalent in modern organizations. Prior research has shown that MTS effectiveness is a function of the quality of both the processes occurring within each component team and between the teams in the system (Marks, DeChurch, Mathieu, Panzer, & Alonso, 2005; DeChurch & Marks, 2006). The critical drivers of both team and MTS effectiveness include behavioral processes (explicit actions directed towards others; e.g., communication), cognitive states (knowledge or perceptions; e.g., transactive memory), and affective states (emotions or mood; e.g., stress) emerging from the shared experiences of the members of the team (Cohen & Bailey, 1997; Marks, Mathieu, & Zaccaro, 2001; Mathieu, Marks, & Zaccaro, 2001).

While these phenomena exist both within and between teams, prior research has shown that such processes and states cannot be assumed equivalent across these levels (DeChurch & Zaccaro, 2010). Further complicating these relationships, these processes and states are expected to impact the relationships that other phenomena have on performance in addition to their expected direct effects (Ilgen, Hollenbeck, Johnson, & Jundt, 2005). With this, the purpose of this thesis is to study the relationships between process, cognitive and affective states, and performance as each exists within and between teams. Central to this purpose is examining the effects of cognitive and affective states on the relationship between process and performance.

These relationships were tested using a laboratory sample of six-person MTSs (N

= 118, n = 708) performing an action- and information sharing-oriented task. Utilizing network analysis, the direct and conditional impact of behavioral process (i.e., communication), cognitive states (i.e., advice relationships), and affective states (i.e., hindrance relationships) within and between teams were captured. It was found that the impact of between-team communication on MTS performance was moderated by between-team advice relationships and the impact of within-team communication on team performance was moderated by within-team hindrance relationships. Together, these findings suggest a need to consider the effects of within- and between-team processes on performance as having different conditional relationships with co-occurring states.

CHAPTER 1

INTRODUCTION

Multiteam systems (MTSs) consist of two or more teams who work interdependently toward the accomplishment of a collective goal (Mathieu, Marks, & Zaccaro, 2001). MTSs are prevalent in modern organizations; notable examples include corporate strategic alliances (Marks & Luvison, 2011), provincial reconstruction teams (Goodwin, Essens, & Smith, 2011), and scientific teams (Murase, Asencio-Hodge, & DeChurch, in progress). To understand multiteam systems, like teams, it is critical to appropriately capture the phenomena that constitute both task- and interpersonal-oriented phenomena at the level at which they exist (i.e., either within or between teams; Kozlowski & Klein, 2000; Mathieu, et al., 2001). The unique theoretical characteristics of the MTS suggest key differences in the mechanisms of these drivers of performance between teams and MTSs (Mathieu, et al., 2001; Zaccaro, Marks, & DeChurch, 2011).

Two substantively different types of these phenomena have been identified in previous research: process and emergent states (Marks, Mathieu, & Zaccaro, 2001). While processes are those actions which directly drive performance, their effectiveness is largely determined by the internal environment (i.e., emergent states) within which they are expressed. Failing to consider process as occurring within the context of emergent states results in deficient understanding of the collective (be it team or MTS) and, ultimately, performance (DeChurch & Zaccaro, 2010; Crawford & LePine, 2013). Further, assuming that the relationships between process, emergent states, and performance are consistent at different levels is a mistake (Kozlowski & Klein, 2000).

Though these assertions are well established in research on teams and MTSs (e.g., Cohen & Bailey, 1997; Zaccaro, et al., 2011), neither have been extensively or consistently heeded as recent calls concerning these issues suggest (see DeChurch & Zaccaro, 2010; Murase, Doty, Wax, DeChurch, & Contractor, 2012; LePine & Crawford, 2013).

Most generally, both the expected expression and impact of a given process is determined by the presence of both other processes and the emergent states (Marks, et al., 2001; Ilgen, Hollenbeck, Johnson, & Jundt, 2005; Mathieu, Maynard, Rapp, & Gilson, 2008). One such process deemed critical to functioning is interpersonal communication (Glickman, Zimmer, Montero, Guerette, Campbell, Morgan, & Salas, 1987; Kozlowski & Bell, 2003; Salas, Sims, Burke, 2005). While the importance of communication may appear intuitively obvious, the current literature struggles to provide a clear understanding of its role in functioning and effectiveness (e.g., Campion, Medsker, & Higgs, 1993; Balkundi & Harrison, 2006). One potential explanation for these inconsistent findings may be the aforementioned issue of emergent states changing the nature and effectiveness of the communication itself. Two such states, cognition (defined as a "representational understanding of the system;" Cohen & Bailey, 1997, p. 259) and affect (defined as the "tone [or emotion] of the group;" Cohen & Bailey, 1997, p. 257; Marks, et al., 2001, p. 363) have been shown to both directly impact and moderate the relationship between interpersonal communication and team outcomes (e.g., Mathieu, Heffner, Goodwin, Salas, & Cannon-Bowers, 2000; Marks, Zaccaro, & Mathieu, 2000; Yoo & Kanawattanachai, 2001; Patrashkova-Volzdoska, McComb, Green, & Compton, 2003; Hinds & Mortensen, 2005; Johnston, Reed, Larence, & Onken, 2007; Sauer, Felsing, Franke, & Ruttinger, 2006; Chung & Jackson, 2013). This thesis will, at its core, provide further insight into the effects of these states on the relationship between communication and performance at both the team and MTS level.

Admittedly, clear support for the conditional nature of the impact of communication on effectiveness already exists in traditional teams research; that is, teams whose members average higher quality communication tend to perform better when certain preconditions exist. However, the strength of these findings is largely limited by the assumption that teams can be accurately represented as simple aggregations of their members (Kozlowski & Klein, 2000). Recent conceptualizations of these units question the validity of this assumption and call for a more sophisticated understanding of the emergent internal structure (DeChurch & Zaccaro, 2010; Crawford & LePine, 2013). That is not to say that no understanding can occur in terms of the shared experiences of individuals, but rather that phenomena must be captured in a manner which reflects their extant nature.

Most simply, collective phenomena can be conceptualized as arising through compositional emergence, wherein a high degree of similarity is expected across all members, or compilational emergence, wherein the assumption of sharedness is rejected in favor of an expectation of meaningful differences across members (Kozlowski & Klein, 2000). The potential impact of these different conceptualizations of phenomena has become widespread and relevant enough to draw the focus of several meta-analyses (see Devine & Philips, 2001; Balkundi & Harrison, 2006; Bell, 2007; DeChurch & Mesmer-Magnus, 2010). Together, these recent meta-analytic findings leave little doubt to the ability of capturing new phenomena or a better understanding of established phenomena by reconsidering the nature of its emergence.

One of the most recent approaches that have been applied to this problem in organizational science is that of network analysis (Borgatti & Foster, 2003; Katz, Lazer, Arrow, & Constractor, 2004). This perspective, including the related analytic techniques, allows for phenomena to be captured compilationally through the representation of collectives as a set of dyadic relationships between all individuals. The set of individuals constitutes the network while the pattern of relationships across every pair of individuals captures the emergent structure of a given phenomenon (e.g., trust or friendship).

The first contribution of this thesis utilizes this network perspective and methodology as it examines the direct relationships between three emergent phenomena (communication, cognition, and affect) and performance at two units of analysis: the team and the MTS. While these techniques are not unheard of in previous research on communication in teams and similar collectives (see Balkundi & Harrison, 2006), this thesis will provide a second, completely novel contribution by examining the aforementioned conditional relationships between communication, emergent states, and performance. As stated by Balkundi and Harrison (2006, p. 63), "In fact, we are not aware of any study that looks at the effect of the interaction between network variables on team level outcomes." This thesis does exactly this in the assessment of the moderated relationship between communication and performance at both the team and MTS units of analysis.

Multiteam Systems

The multiteam system (MTS) is a unique collective work arrangement that is composed of two or more interdependent teams working towards a common goal. Critical to the definition of an MTS is the existence of functional interdependence between all component teams (Mathieu, et al., 2001). Functional interdependence exists between teams that must share inputs (e.g., equipment, information, resources, etc.) and interact with one another to complete one or more goal(s). This does not necessarily mean that each individual member or team within the MTS is interdependent with all other members, but rather that each is functionally interdependent with at least one other member. This is one way in which MTSs can be differentiated from more traditionally defined teams and organizations. All members of a team are expected to have functional interdependence with every other member while organizations are often composed of actors which may be essentially independent from one another.

Similarly, the problems that an MTS is assembled to handle are multi-faceted such that there are distal goals towards which the entire MTS works and proximal goals which have varying levels of interdependence between the actors. The manner in which the goals of the component actors of the MTS fit in with one another is referred to as the goal hierarchy indicating the extent to which the goals of each actor may work towards, be neutral to, or even work against the overall MTS goals. Such mixed-motive goal structures create a complex pattern of interaction between the actors in order to satisfy all goals within the hierarchy of the MTS. This is further exacerbated by the comparatively high levels of interdependence expected within MTSs (Marks, et al., 2005).

Complexity in Multiteam Process

Performance in a multiteam system is most appropriately explained using a similar model as what is used to explain team processes proper, the Input-Process-Outcome (IPO) model (Mathieu, et al., 2001). Though processes derived from the team-level IPO model act as a solid foundation from which the research of MTS may be built, our understanding of these processes cannot be assumed to hold across levels (DeChurch & Zaccaro, 2010). Because there is currently a dearth of research on multiteam process, team processes serves as the most reasonable analogue. There is a specific set of inputs that is then converted to an output to fulfill the proximal goals based on the mediating internal states and processes. The potential of the outputs to have usefulness towards completing the MTS goals is highly variable even as the goal hierarchy is held constant. Most importantly, the performance of the MTS is not just the simple aggregation of the performance of the component actors. Conversely, the performance of the component actors on their respective proximal goals will only lead to success on the super-ordinate MTS goal if the actors' outputs are appropriately aligned. The quality and the alignment of the outputs created by the component actors will be driven by the processes and states that exist within the MTS. With this, the first core contribution of this thesis is to provide further understanding of how the emergent states and behavioral process affect collective performance at the team and MTS levels.

Previous research on multiteam systems has supported much of the theoretical development regarding its importance and uniqueness as a collective structure. DeChurch and Marks (2006) supported the idea that the performance of a MTS cannot be decomposed strictly to the performance of the component teams, finding that after controlling for intra-team coordination and team performance, inter-team coordination still accounted for unique variance in even a small two-team, six-person MTS. This highlights why the profound effect that the complexity found within an MTS differentiates it from simpler organizational forms, such as teams, and suggests a need to evaluate the unique effects that internal processes have on performance.

Internal process is a set of behaviors that is expected to be related to the quality of outcomes of teams. There are several conceptualizations of process (e.g., Marks et al., 2001; Salas, et al., 2005; Tuckman, 1965) and the predictive weight of each individual behavior is not expected to be constant across situations. For instance, Zaccaro and colleagues (2000) discusses the role of functional leaders as doing or getting done whatever it is that the team currently requires. Thus, a team with a single overwhelmed individual will be successful to the extent that backup behaviors occur while a team with a lot of dissenting opinions will be successful to the extent that conflict management occurs. Because of these ambiguities, there is a lot of variation in the study of process throughout the literature, but there are several fairly consistent core components.

Interpersonal communication is one such process that is expected to be essential to the functioning in most teams as it is often, but not always, a precursor of coordination (Brannick, Prince, Prince, & Salas, 1995; Rico, Sanchez-Manzanares, Gil, & Gibson, 2008). Simply knowing that a group communicated a lot (or a little) does not allow you to directly infer that it the relationship with performance will be positive (or negative). Thus, the overall functionality of the communication must also be assessed and can be done by capturing the content and/or pattern of communication behaviors between individuals. While examining the content of the communications may provide an indication of the overall quality of the process, the pattern provides important information about how and where information sharing and coordinating activities were taking place. Though understanding the quality remains important, the complex structure inherent to the MTS greatly accentuates the need to account for the pattern of behavioral processes occurring both within and between component teams.

Attending to the Structure of Team Process through Network Analysis

Network analysis is the methodological component of the network perspective or network lens which describes both a different way of measuring and conceptualizing interpersonal phenomena. The network perspective has gained popularity in organizational research over the past several decades as focus on purely individual-level theories have been replaced by a preference for interpersonal, collective, and system-level explanations (Borgatti & Foster, 2003). The basic unit of analysis of the network perspective is the relationship (that is, focused on what is occurring between two or more individuals), rather than the individual as in traditional organizational science. Network analysis is also inherently multilevel such that individuals are understood in terms of their place in the system and the system is understood in terms of the pattern of individuals. Taken together, a set of individuals is referred to as the network which contains a unique set of relationships occurring between each pair of the individuals.

In its most basic form, a network is a set of nodes or actors each representing some entity (e.g., a(n) individual, city, idea) which are connected to one another via a set of edges or ties representing some relationship (e.g., liking, distance, similarity). Conceptualizing collectives (or any set of related actors) as a network provides a unique perspective which offers a unique and powerful framework for understanding relevant phenomena (Burt, 1987; Katz, et al., 2004). Unlike traditional conceptualizations, phenomena as networks are understood in terms of the structural properties of the observed relationships between nodes. Further, the core interest of the network perspective is to understand either the mechanisms that account for different observed structures or the impact these observed structures have on other phenomena (Borgatti &

Halgin, 2011). Structural properties describe different facets of the specific pattern of the observed relationships within a network that can be expressed as simple numeric indices. These properties are myriad but include such indices as density (the observed intensity of the relationship across every pair of actors), reciprocity (the structural tendency towards the existence of shared relationships within each pair of actors), and centrality (the tendency towards greater difference between the most and least connected actors). Structural properties have long been theorized to impact other phenomena directly (e.g., Leavitt, 1951; Shaw, 1964; Granovetter, 1985) and capture substantive phenomena themselves (e.g., Bonacich, 1987; Feld, 1981).

As both the popularity and understanding of the network perspective has increased in organizational research, so has it been applied to teams and similar collectives in increasingly sophisticated ways. The effects of different structural properties in teams have been supported both for relationships occurring entirely within the team and those directed at some set of actors external to the team (Borgatti & Foster, 2003). Though such research is relatively common, there is wide variation in the voracity of the connection between the studied network structures and the theorized psychological phenomena. Some forays of the network perspective into teams research (or vice versa) fail to meaningfully integrate network methodology and traditional process theories to the detriment of the intended contribution.

It is essential that when the network perspective is utilized, it complements the established theoretical underpinnings of the substantive psychological phenomena rather than existing outside of it. A recent and prototypical example of such complementary theory building is that of the configural theory of team process as presented by Crawford and LePine (2013). This theory seeks to explain the effects of structural properties through the mechanisms of established team phenomena and vice versa. Additionally, the authors clearly explicate the need “to think differently about team processes, with the result being explanations of team functioning and effectiveness that are more integrative and complete” (Crawford & LePine, 2013, p. 43). Inherent in this goal is the need to consider the complementary nature of compositional and compilational emergence. By accounting for processes and states both as shared experience throughout the collective and patterns of idiosyncratic experiences across individuals, novel substantive contributions may be made. Consistent with the network perspective and Crawford and LePine’s theory, the hypotheses of this thesis are framed such that team phenomena (behavioral process, cognitive state, and affective state) will be discussed in terms of both compositional and compilational emergence.

Communication Density as Behavioral Process

Interpersonal communication is expected to occur frequently within an interdependent collective as nearly all other processes are funneled through these behaviors (Cohen & Bailey, 1997). In their taxonomy of team process, Salas and colleagues (2005) propose communication as being an essential mediating mechanism through which all other processes depend. In addition to simply distributing information and allowing for coordination, communication is expected to impact the formation of necessary cognitive and affective states. Though not considered from the network perspective, Salas and colleagues (2005) suggest the expectation that both the amount and pattern of communication are important. This is referred to as *closed-loop communication* indicating the importance of, for one, the aforementioned structural property of reciprocity.

Issues concerning the structural properties of communication relationships within collectives has been long studied in organizational science (e.g., Leavitt, 1951; Cohen, Bennis, & Wolkon, 1962; Shaw, 1964). The most basic of these captured the general tendencies and patterns of how people interact with one another and the overall structure these interactions create. While much of this early work focused solely on the meaningfulness of the structural properties in and of themselves, Shaw (1964) identified several communication structures theorized to have differential effects on processes and outcomes. Similarly, Lanzetta and Roby (1956) assert that the limiting factor of group process is not information capacity, but rather the effectiveness of the communication structure the group develops.

The Effects of Communication on Team Performance

Evidence for the impact of both the amount and the structural properties of communication has been found in previous research. Most basically, the amount of communication occurring within teams and similar collectives tends to be positively related to objective measures of performance (Campion, Medsker, & Higgs, 1993; Reagans & Zuckerman, 2001; Cummings & Cross, 2003). With this, communication has consistently been espoused as having an essential role in team performance and that more is almost invariably better. However, there is evidence that casts doubt on both the consistency and criticality of communication as a driver of team effectiveness. In a recent meta-analysis, Balkundi and Harrison (2006) found only a very weak relationship between team performance and the strength of communication relationships (ρ = .15).

While the estimated true effect of communication is positive, it was found to be much weaker than one may expect as most critical team processes (e.g., information sharing, leadership, etc.; Salas et al., 2005) are, at least partially, dependent on some form of interpersonal communication. Rather than communication having no meaningful relationship with team performance, it may be that the relationship is simply more complex (Gladstein, 1984). Some evidence exists that there may be a curvilinear relationship between the amount of communication and performance (Patrashkova-Volzdoska, et al., 2003) while others show differential relationships due to the current team phase (Hackman & Morris, 1975; Weingart, 1992), stage in the lifecycle (Futoran, Kelly, & McGrath, 1989; Entin & Serfaty, 1999), or environmental constraints (Urban, Bowers, Monday, & Morgan, 1995; Marks, Zaccaro, & Mathieu, 2000). Important though these factors may be, there is a standing expectation in the value of considering the structure of interpersonal processes, such as communication, as they exist (Murase, et al., 2012; Crawford & LePine, 2013).

One such consideration termed *pattern flexibility*, was originally proposed by Leavitt in 1951 to have a critical role in determining the functioning of a group. Pattern flexibility captures the amount of redundancy in the available communication pathways within a group of people. That is, pattern flexibility increases with the number of different paths each person may be able to access in order to reach any other person and is directly related to the number and strength of communication relationships within a group. In support of these expectations, moderate to strong correlations (r = .54) between team communication and flexibility have been found, indicating higher quality teamwork and greater team adaptability (Stewart & Barrick, 2000). Such studies on team functioning provide additional evidence of the relationship between communication and flexibility such that communication in and of itself is more impactful on performance when it is required. Marks and colleagues (2000) found that communication had no relationship on performance during a routine task, but explained as much as 14% of the variance in performance during a novel task.

Further, considering the role of network structures, Stachowski, Kaplan, and Waller (2009) found communication structures precipitating good performance in routine situations were distinct from those that were successful in novel situations. Similarly, different structural properties within teams, specifically centralization, has been shown to moderate the effect of communication on performance. Greater amount of communication was found to have a negative relationship with performance when the structure was more highly centralized and positively related to performance when the structure was less centralized (Urban, et al. 1995; Sauer, et al., 2006). Overall, these findings suggest a positive, though highly variant, relationship between communication amount and team performance. With this, it is hypothesized that:

Hypothesis 1a: Intra-team communication network density will be positively related to team performance.

The Effects of Communication on Multiteam System Performance

While similar complexities of the potential effect of communication on performance can be expected to exist at the MTS level as well, its functional impact may utilize a different mechanism altogether. There is general agreement that appropriate interactions between the team and its external environment are essential for group functioning (e.g., Campion, et al., 1993). The nature of interdependencies between the teams within an MTS must be understood to determine what may be deemed "appropriate interactions" and, as the MTS is a well-defined collective, such understanding is feasible. Proper MTS functioning requires contributions from each component team above and beyond the solely team-level phenomena in order to coordinate the lower level processes into performance on the ultimate distal goal(s).

With this, previous MTS research has found complex relationships between team- and MTS-focused coordinating behaviors (e.g., Marks, et al., 2005). Similarly, though their research was not focused on MTS phenomena specifically, Cross and Cummings (2004) found that an individual's relationships to others outside of their department, organization, hierarchical levels, or across physical barriers are all positively associated with performance at the individual level. From the network perspective, Baldwin, Bedell, and Johnson (1997) found that the expansiveness of team members' interpersonal networks outside of the team was associated with more functional team interaction process.

Further understanding of these inter-team relationships comes from one body of research which focuses on the effects of the external process termed team boundary spanning. Marrone (2010, p. 912) defines team boundary spanning as "a team's efforts to establish and manage external linkages… within an organization… or across organizational boundaries." This theory recognizes the importance of teams' work in coordinating tasks with external entities, seeking information, and maintaining identity. Boundary spanning behaviors by members are expected to impact individual performance similarly to team boundary spanning on team performance.

Though it has generally been found that boundary spanning is a positive predictor in team outcomes such as innovation, efficiency, and goal attainment, the literature is far from unilateral. For instance, Joshi, Pandey, and Han (2009) propose a contingency model of team boundary spanning behaviors which predicts the expression of different behaviors in different contexts. Thus one would expect that boundary spanning itself cannot be assumed to be universally related to outcomes at any level. This assumption can be seen playing out in Marrone, Tesluk, and Carson (2007) as boundary spanning behaviors being found to be positively related to role overload. However, it is important to note that the extent to which the rest of the team boundary spanned was negatively associated with individual member overload. Overall, this indicates that if individuals within a team tend to work across their boundaries, process and outcomes tend to benefit as long as members are not overwhelmed. Applying this to the MTS suggests a generalized expectation of improved system performance to the extent that individuals engage in externally-focused behaviors. With this, it is hypothesized that:

Hypothesis 1b: Inter-team communication network density will be positively related to MTS performance.

As aforementioned, the effects of behavioral process and the specific impact of the structure that said can take are highly related to collective outcomes in and of themselves. However, it would be a mistake to discount the impacts of the states that emerge between individuals within a collective as they interact with one another (Cohen & Bailey, 1997; Salas, et al., 2005). Previous research has shown almost unanimously that such states have substantive impact on outcomes as well as on behavioral processes themselves (Kozlowski & Ilgen, 2006; LePine, Piccolo, Jackson, Mathieu, & Saul, 2008). As aforementioned, such states are commonly split into the categories of cognitive, consisting of understanding and knowledge, and affective, consisting of tone or emotions, which are expected to have differential impacts the on the team (Marks, et al., 2001). It is important to recognize that in addition to shaping behavior directly, such states are expected to simultaneously impact the manner in which behaviors are interpreted and utilized to complete the team tasks and goals. With this, it is essential to first account for the strength of specific states, but then also account for the structures existing across both the states and processes.

Advice Relationship Density as Cognitive State

Cognitive states have been defined in several different ways, but at the core, this phenomenon represents the information and knowledge that exists within a collective (Marks, et al., 2001). There is little agreement on the most appropriate constructs to meaningfully capture this and prior research elaborates on a wide variety of collective cognitive constructs ranging from shared understanding (Hackman & Morris, 1975), to shared mental models (Mohammed, Ferzandi, & Hamilton, 2010), to transactive memory systems (Wegner, 1987). Despite this, previous research has shown generally weak to moderate positive relationships with team outcomes which have been supported meta-analytically (DeChurch & Mesmer-Magnus, 2010). Similar significant results are expected to exist for similar conceptualizations of cognitive states to the extent that it captures some facet of relevant knowledge or understanding that exists in the collective (Fiore & Salas, 2004). One such conceptualization is that of Cohen and Bailey (1997, p. 259), who define the "collective mind" as "the interrelation of actions carried out within a representational understanding of the system… developed by each actor in the system." Within this perspective one may assess the cognitive state by capturing the pattern of knowledge present across the members of the network. A similar conceptualization adopted from the network perspective is that of the structure of advice ties. These ties represent each member's perception of the extent to which he was provided useful information by each other individual in the network (e.g., Wong, 2008).

Conceptualizing the Advice Network

Within any interdependent collective, relationships exist through which valuable information and knowledge flow between the members. This pattern of relationships forms the informal advice network which is emergent rather than strictly implemented directly within the defined collective hierarchy (Sparrowe, Liden, Wayne, & Kramer, 2001). Thus, the way in which individuals share informational resources and collaborate may differ drastically from both the formal structure of the network and between any given set of networks. Previous research has found that the density of these relationships has a significant impact on the perceived effectiveness of project groups even after controlling for group size, cognitive ability, and interdependence (Wong, 2008). Balkundi, Barsness, and Michael (2009) further supported the assumed importance of advice relationships within relatively small collectives finding strong effects on team viability. Similarly, Bono and Anderson (2005) were able to account for variance in the display of functional interpersonal behaviors by considering the different structural properties of advice relationships.

Rather than being a measure of behavioral process, though, it is legitimate and possibly preferable to conceptualize these relationships as indicative of a cognitive state such as the aforementioned collective mind. As explained by Wegner (1987), a core component of such cognitive states requires individuals to both determine the location and how to retrieve relevant information. Though Wegner (1987) was discussing the transactive memory construct specifically, the similarity with Cohen and Bailey's (1997) espoused need for considering cognitive states a representational understanding developed by each individual, is clear. Before the wide spread use of standardized perceptual measures (e.g., Lewis, 2003), research on this construct utilized observed behaviors which indicated the extent to which different individuals hold specialized information and that team members are seen as credible (Liang, Moreland, & Argote, 1995).

The Effect of Cognitive State on Collective Performance

The first component, specialization, is thought to be observed when team members display behaviors which indicate the existence of unique knowledge across individuals. The second component, credibility, is thought to be observed when team members show a perception of belief in others' expressed knowledge. The construct of advice relationships is expected to capture similar components of the cognitive state of the network. First, people will not seek out information they already have and will not value redundant information provided to them. Second, people will not seek out or perceive as valuable information from an individual that lacks credibility (Nebus, 2006). Recalling the definition of advice ties, such a relationship only exists when an individual is perceived to both have and provide valuable information. Within an entire network, the pattern of these relationships captures both the locations and flow of information. Essentially, to the extent that each team member is aware of the knowledge stores of each other person, the denser the advice network can be expected.

Previous research conceptualizing cognitive states as knowledge relationships within a network has shown significant relationships with collective outcomes. Akgun, Byrne, Keskin, Lynn, and Imamoglu (2005) found that project development teams with more expansive understanding (denser network structure) of one another's specialization of knowledge perform better, more efficiently, and utilize a wider base of relevant information. Additionally, such teams tend to have higher quality internal affective states and report more effective behavioral processes. Similarly, Ellis (2006) found that the extent to which information was appropriately provided to the people who needed it and retrieved from the people who had it positively impacted performance. Beyond those studies which consider cognitive states in terms of dyadic relationships, more traditional assessments have been found to have similar meaningful effects on performance meta-analytically (DeChurch & Mesmer-Magnus, 2010). Both traditional and network oriented conceptualizations appear to tap very similar aspects of cognitive states and have found relatively consistent, positive relationships with performance. With this and the pattern of the aforementioned research indicating the relationship between advice relationships and team performance, it is hypothesized that:

Hypothesis 2: (a) Intra-team advice network density will be positively related to team performance. (b) Inter-team advice network density will be positively related to MTS performance.

Hindrance Relationship Density as Affective State

Affective states encompass the social environment within which team processes occur including phenomena such as trust, liking, and conflict (Cohen & Bailey, 1997; Marks, et al., 2001). As aforementioned, these states have been shown to consistently impact behavioral process and outcomes of collectives. These effects are theorized to exist because of their direct influence on behaviors through motivation and attitudes towards individuals, task, or the collective as a whole (Chen & Kanfer, 2006). High levels of positive affective states are expected to yield behaviors which enhance functional interpersonal behaviors such as open communication, information sharing, back-up behaviors, social exchange, and emotional support as well as acting as buffers against stress, exhaustion, and conflict while high levels of negative affect are expected to detract from such behaviors and exacerbate difficulties. Team affective states emerge through complex processes, but are expected to be largely influenced by the interpersonal behaviors and attributions of said behaviors by the members of the team (Brewer & Kramer, 1985). Because individuals have finite cognitive resources, others' behaviors and, in turn others themselves, are mentally categorized (e.g., trustworthy-untrustworthy, helpful-unhelpful, liked-disliked). These categorizations are then used to both predict and interpret future interactions and guide one's own future behavior. By tapping the affective value of these categorizations across the members of the collective, it is expected that one can accurately capture the affective climate that exists and thus account for its effect on subsequent process and performance.

Conceptualizing the Hindrance Network

Previous research has generally measured affective states as a compositionally emergent attribute of the collective dictated by similar relationships across individuals. Though this may be a reasonable assumption in some unique cases, there is no reason to assume that relationships between individuals within a collective will tend towards uniformity. For example, if Person A and Person B dislike Person C, there is no reason to assume that Person A and Person B also dislike each other. Additionally, as collectives become larger and more complex additional concerns may arise. The potentiality of subgroups, for one, requires accounting for the affective state as compilationally emergent (Cronin, Bezruka, Weingart, & Tinsely, 2011). The affect between members within the same subgroup are expected to be different than those between members across subgroups simply as a function of differential membership (Hewstone, Rubin, & Willis, 2002; Joshi, Labianca, and Caligiuri, 2002). If affect is assumed to emerge compositionally, such a detail would be completely immeasurable.

While many traditional measures of affective states ask respondents to consider their emotions towards the team as a whole (rather than each individual), compilational measures are not amenable to such a referent shift. This has resulted in previous research having difficulty measuring negative attitudes towards others (Sparrowe, et al., 2001). In an effort to solve this problem, there has been a move towards the use of proxies in order to capture negative phenomena. That is, rather than asking an individual to single out another with whom he has a negative relationship, ask the individual to identify who engages in some objectively inappropriate or dysfunctional behavior.

A widely used proxy for negative relationships between individuals is that of hindrance which is expected to capture the inherent affective responses to several dysfunctional behaviors "including annoyance, emotional upset, and anger" (Sparrowe, et al., 2001, p. 318). Hindrance relationships are most often conceptualized to represent a wide range of dysfunctional behaviors relating to both active (e.g., sabotage) and passive (e.g., avoidance) interference. Previous research has found individual and group level performance to suffer to the extent that hindrance relationships are dense (Xia, Shami, Yuan, & Gay, 2007; Labianca & Brass, 2006; Yang & Tang, 2004; Sparrowe, et al., 2001). With this, hindrance relationships are expected to capture at least one facet of the affective state within both teams and the MTS and, thus, it is hypothesized that:

Hypothesis 3: (a) Intra-team hindrance network density will be negatively related to team performance. (b) Inter-team hindrance network density will be negatively related to MTS performance.

Emergent States as Moderators between Process and Performance

Emergent states are considered to indicate the environment within which process occurs and are expected to shape both the behaviors that are expressed and their subsequent impact on performance (Marks, et al., 2001; DeChurch & Mesmer-Magnus, 2010). Specifically, the quality of the cognitive states within the collective will impact the type of information that is communicated, the how communication will affect future behavior, and the likelihood of further interpersonal interactions (Fiore & Salas, 2004). As aforementioned, previous research has consistently supported this expected relationship. Though the existence of such a relationship is well established, the exact nature of said is far from understood. For instance, Mathieu and colleagues (2000) found that team process mediated the relationship between cognitive states and performance. However, in a recent meta-analysis, DeChurch and Mesmer-Magnus (2010) found that cognitive states explain a significant amount of additional variance in performance even after controlling for behavioral process and affective states. This supports the presence of mechanisms relating cognitive states and performance beyond those simply driving changes in behaviors. Not accounting for such mechanisms will likely lead to deficient understanding of the effects cognitive states have on outcomes.

Similar relationships are expected to exist between affective states, behavioral process, and performance. Rico and colleagues (2008) propose a model wherein affective states impact future behavioral processes by coloring the manner in which past information and behaviors are interpreted. That is, the likelihood of different future processes is impacted by affective states, but there is no expectation of the same process having different outcomes influence by the extant affective states. Similar to the relationships found between cognitive states, behavioral process, and performance, evidence for such effects exists. A recent meta-analysis on team cohesion (an affective state) found a positive relationship between both cohesion and behavior and performance, but still concede the need to assess factors which can be expected to moderate the observed relationships (Beal, Cohen, Burke, & McLendon, 2003). These findings yield the expectation that both the expression and impact of processes are substantively related to the co-occurring affective states. As such, they are expected to emerge simultaneously and impact each other reciprocally (i.e., behaviors influence the affective state which, in turn, impacts the behaviors expressed). This results in ambiguity of both the precedence and impact that any given state has on process and vice versa. Which begs the question, how may states and processes interact with one another in order to impact performance (Mathieu, et al., 2008)?

Moderating Mechanisms of Emergent States

Practically, such a question may be untenable as reciprocal relationships are expected to exist in the emergence of affective and cognitive states and behavioral processes as collectives develop over time (Ibarra, Kilduff, & Tsai, 2005). Despite the theoretical and practical difficulties of establishing true precedence across these compound effects, empirical evidence supporting these complex relationships exists. This evidence largely takes the form of the moderation of the behavioral process to performance relationship due to both cognitive and affective states. Looking first to the support of cognitive states as a moderator, several potential relationships have been studied.

For example, Bendoly and Swink (2007) provide evidence establishing potential mechanisms through which such effects may arise. Their findings indicated that the extent to which a given individual within a decision making team was able to appropriately provide and request information was impacted by the amount of information sharing behaviors displayed by other team members. The observed positive impact of these behaviors was increased to the extent that the focal individual had understanding of the information that was distributed within the team. These findings indicate a clear moderating effect of both information oriented process and cognitive states on the effectiveness of subsequent behavioral processes. Further, these results are of particular importance as the moderated behavioral processes themselves have a positive direct effect in determining performance even when co-occurring cognitive states and processes are not considered (Mesmer-Magnus & DeChurch, 2009).

Similar relationships have been found with affective states moderating the behavioral process to performance relationship. The strength of the relationship of behavioral process on performance has been shown to be influenced by both positive and negative emergent affective states. A belief that the team has well defined goals and a clear direction was found to strengthen the relationship between process and performance while feelings of being overwhelmed and poorly supported weakened the same (Janz, Colquitt, & Noe, 1997). One potential explanation for these relationships is that the affective state captures a component of process that simply cannot be captured when considering overt behaviors alone.

When behavioral processes are themselves measured to be value laden, rather than simply capturing the presence of certain types of behaviors (e.g., communication v. conflict behaviors), evidence for these moderated relationships remain. Team conflict behaviors have been consistently found to have a negative relationship with team performance even though positive effects are often hypothesized (De Dreu & Weingart, 2003). However, recent research has found that these consistent negative effects may be moderated by psychological safety (a positively valenced affective state) such that when it is high, high levels of task conflict actual improve team performance (Bradley, Postlethwaite, Klotz, Hamdani, & Brown, 2012). On the flip side, other research has called into question the universality of behavioral processes long supported to be important and beneficial. Harrison, Price, Gain, and Florey (2002), for one, studied the effects that the perception of deep-level diversity moderated the impact of collaboration on team functioning. It was found that high levels of diversity reversed the expected positive relationship between time spent collaborating and perceived functioning.

Moderation of Communication by Emergent States

In terms of the specific behavioral process that is of interest to this thesis, relationships with communication and both cognitive and affective states have been theorized. An essential component of effective communication is theorized to be the establishment and maintenance of mutual knowledge (Driskell, Radtke, & Salas, 2003). This cognitive state captures the extent to which each individual has and is able to recognize knowledge common across the team. This state is expected to impact the efficacy of communication through the use of common language and interaction norms.

Thus, this cognitive state is expected to moderate the relationship between the amount of communication and team performance (Wittenbaum, Stasser, & Merry, 1996).

In terms of affect, the efficacy of communication is expected to be critically impacted by states such as conflict (Gersick, 1988) and trust (Salas, et al., 2005). The relationship between amount of communication and performance has been shown to be moderated by the trust such that the amount of communication is more impactful when trust was low (Jarvenpaa, Shaw, & Staples, 2004). This may seem counter-intuitive, but simply indicates that lower levels of trust result in a stronger relationship between communication in performance not that lower levels of trust improves performance. Taken this way, the moderated relationship is simply explain as individuals will prefer to be able to oversee what others are doing when lower levels of trust exist.

Though support for moderated relationships due to both cognitive and affective states clearly exist, it is important to note that support has largely come from effects found in smaller, less complex teams wherein the phenomena of interest were measured compositionally. That is, both the direct and moderated relationships assume little variance in the expression of the phenomena across individuals. Currently, there is little to no evidence capturing the effects of the moderated relationship accounting for the structural properties of both the direct and moderating phenomena (Balkundi & Harrison, 2006). The complexity inherent in multiteam systems, however, necessitates accounting for these structural properties in addition to the more commonly considered intensity. With this, an analytic method that appropriately accounts for the compilational nature of the phenomena involved in these moderated relationships must be utilized (Kozlowski & Klein, 2000).

Structural Alignment as an Emergent Phenomenon

Assessing emergent states and processes compilationally (i.e., accounting for structural properties) provides a new potential insight in the conceptualization of moderation of the behavioral process to performance relationship in collectives (Balkundi & Harrison, 2006; Crawford & LePine, 2013). Rather than assessing collective phenomena as linear aggregations of their individual level constituents, more meaning is retained when the phenomena at the collective level are measured in a way that accurately captures how they emerge. Network analysis is able to accurately capture these compilationally emergent phenomena by accounting for the entire structure as it exists between each pair of individuals. Assessing and comparing the structural properties of the states and process of interest allows for a novel method of capturing potential moderated relationships. Traditionally, co-occurrence of different emergent phenomena is solely captured at the collective level as either direct measures or aggregated individual perceptions. That is, a team with a certain overall level of one phenomenon is likely to have a certain overall level of some other phenomenon.

These methods say nothing of the potential similarity or difference of the intensity of the co-occurring phenomena that occurs within each person. This indicates a critical loss of specificity due to the inability to account for the differences in the structural properties of the states and process occurring across all individuals. For example, while a team may have similar overall intensity between a given state and process, any given individual may perceive a high level of one and a low level of the other or vice versa. Further, each individual is likely to have different perceptions of these as states as they exist between themselves and certain others within the collective. From the network perspective, examining the tendency for the co-occurrence (or lack thereof) of multiple phenomena between pairs of individuals can be conceptualized as multiplexity.

Multiplexity of Collective States and Process

Multiplexity is defined as “the degree to which pairs of individuals are linked by multiple relations” (Tichy, Tushman, & Fombrun, 1979, p. 508). This structural property is often used to assess the strength and resilience of interpersonal relationships (e.g., does a relationship exist because of professional or personal association or both?). Similarly, it has been used to capture a more complete understanding of a complex set of interpersonal phenomena. Such an approach was utilized by Yang and Tang (2004) who studied the structures of hindrance, advice, and leadership relationships within a network. Their research questions considered the tendency of co-occurrence between both hindrance and advice relationships as well as hindrance and leadership relationships. When conceptualized in this manner, multiplexity gains the more technical definition of displaying structural properties such that “the probability of [a tie] of one relational type… is elevated above chance levels if there is [a tie] of another relational type” (Agneessens & Skvoretz, 2012, p. 1525). The term *structural alignment* will be used throughout the rest of the thesis to indicate this, more theoretically meaningful, definition of multiplexity occurring between two phenomena.

Structural alignment accounts for the specific co-occurrence of phenomena that exist between every pair of individuals and calculates the collective-level tendency towards co-occurrence of these relationships at this dyadic level. While co-occurrence is measured at the dyadic level, the overall tendency is aggregated to the level of the entire network such that a single index will capture this structural property between each pair of phenomena. Thus, for a collective whose member's tends to engage in behavioral process towards others with which they have a strong affective state, structural alignment will be found (see Figure 1a). For a collective whose members tends to engage in behavioral process towards those with whom they have a weak affective state, structural contra-alignment will be found (see Figure 1b). Finally, for a third collective whose members have no tendency to engage in behavioral process towards those with whom that have either a strong or weak affective state, structural misalignment (Figure 1c) will be found. Most simply, across the whole set of dyadic relationships within a network, a tendency towards multiplexity will yield structural alignment across phenomena while a tendency away from multiplexity will yield structural contra-alignment.

Using the phenomena of interest in this thesis to exemplify the concept of structural alignment, a team may tend to communicate more with individuals with whom they have strong advice relationships. This set of relationships would result in high multiplexity and thus structural alignment. Conversely, a team may tend to communicate less with individuals with whom they have strong hindrance relationships which results in low multiplexity and thus structural contra-alignment. Lastly, it may the case where there is no tendency for communication to be directed towards or away from either strong advice or hindrance relationships resulting in only incidental multiplexity and structural misalignment (i.e., zero alignment). Previous research has largely revolved around the degree of multiplexity existing between the structures of formal and informal relationships. This research has found evidence that the alignment of these relationships has a significant impact on performance (Allen, James, & Gamlen, 2007; Kratzer, Gemunden, & Lettl, 2008).

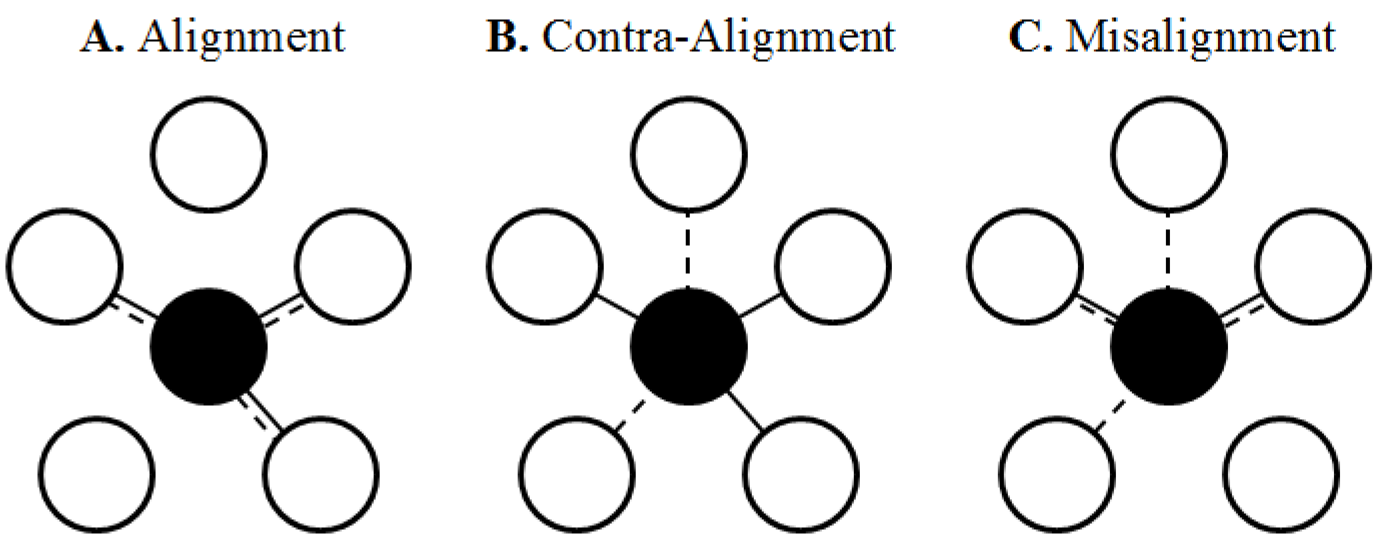

Figure 1: Illustrative example of structural alignment, contra-alignment, and misalignment from the perspective of a single ego-net.
Note: Solid lines indicate process relationships and dashed lines indicate state relationships.

The Nature of Structural Alignment

It is important to note that multiplexity and structural alignment do not measure the compound strength of relationships (i.e., neither the sum nor cross-product of two or more variables); there is no implicit assumption of the absolute or relative strength of a given set of relationships due to their degree of structural alignment. That is, the degree of structural alignment is analogous to a bivariate correlation in that it contains no information regarding intensity beyond the extent to which value of the two variables hang together. High levels of structural alignment between two phenomena indicate only that the two tend to co-occur. Neither the overall intensity of either set of relationships compared to some third relationship nor even comparing one another can be assessed using this index.

With this, to fully capture the effects that structural alignment may have, it is necessary to also account for the absolute strength or amount of, at least, one phenomenon. This can be done by calculating a cross-product between the density of one phenomenon of interest and the calculated structural alignment. Theoretically, this interaction term captures the extent to which the relationship between the independent phenomenon and the outcome of interest is impacted by the structural alignment between the independent phenomenon and some other phenomenon. For example, the relationship between the amount of communication (density of communication relationships) and performance may be moderated by the extent to which communication and advice relationships are structurally aligned with one another.

This is of particular interest to this thesis in respect to understanding the differential impact of the amount of communication on performance due to the variance in the structural alignment (or contra-alignment) between communication, advice, and hindrance relationships. Traditionally, such a moderated relationship will be tested through the calculation of the cross-product of the simple collective-level linear aggregations of the independent (amount of communication) and moderator (intensity of the cognitive or affective state) variable. However, this method fails to consider potential effects due to the patterns of the phenomena that exist within the collective across phenomena. The nature of such moderated relationships is not expected to differ vastly when assessed through structural alignment, but rather should be more easily detected due to the increased sensitivity of the measurement. However, because the nature of emergence of structural alignment is different from much of the extant literature, it would be inappropriate to simply assume the theorized mechanisms precipitating these relationships are identical to those assessed compositionally.

Principles of Balance Theory as a Mechanism of Moderation

To properly frame the hypothesized moderation effects of alignment it is important to first conceptualize how these phenomena relate to one another in a more general sense. To do this, a variation on the framework of Heider's balance will be utilized. This theory proposes the mechanisms through which relationships between individuals are expected to develop based on the presence of other, co-occurring relationships (Cartwright & Haray, 1956; Anderson, 1971). Balance theory was developed specifically as a cognitive solution to the problem of understanding the psychological impact of different patterns of relationships between individuals. Despite generalizations and advancements over the intervening decades, the core tenets of the proposed theory have been consistent. Specifically, psychological discomfort arises in systems that are not balanced.

Balance indicates a relational structure between any two individuals that requires at least one party to hold two contrasting opinions. Whether balance or imbalance exists must be done by examining the *balance graph* which represents the relevant nodes and relationships required to make the determination. For instance, the simplest balance graph consists of three nodes and one relationship connecting each possible pair of nodes. That is, if the two individuals in a dyad (persons A & B) both like or dislike some target (person C), and like each other, there is balance. However, if persons A and B both like each other, but A likes C and B dislikes C (or vice versa), there is imbalance. The reason for this imbalance is because the relationships with the target (person C) by each of the two in the dyad of interest (persons A & B) are mismatched, while the two focal individuals consider their own relationship to be matched. The early conceptualization of balance theory only indicated that there would be a tendency for change in the relational structure due to these imbalances. Subsequent advances, however, have postulated more psychologically meaningful mechanisms through which imbalances drive change, such as cognitive inaccuracies/restructuring (e.g., Krackhardt, 1987), relational maintenance (e.g., Alessio, 1990), and self-consistency (Jones, 1973). These extensions of balance theory yield additional potential impacts of psychological imbalance beyond simple changes to the common relationship connecting the dyad and target.

Balance theory does not require that relationships only represent preference (i.e., like v. dislike) and there is no need for the relationships to be consistent across the whole of the balance graph. For instance, Davis (1963) uses the example of Romeo and Juliet to indicate imbalance across liking and what he terms the *unit relationship* which, in this case, is group membership or association. To paraphrase Davis: Juliet likes Romeo, Juliet dislikes Montagues, and Romeo *is* a Montague; wherein Romeo's membership to the group Montague is a unit relationship (see Figure 2a). This same set of relationships may be reconceptualized as a set of four nodes (Juliet, Romeo, Capulet, and Montague) such that liking or disliking may exist between the targets of the unit relationships (Capulet and Montague), directly (see Figure 2b).

The concept of the unit relationship is not relegated to only indicating the membership to some group, but also includes value (e.g., religion, political party affiliation, etc.) and individual characteristics (e.g., age, intelligence, socioeconomic status). This is a well-worn concept as it is the expected basis of many interpersonal attribution processes (e.g., group bias, social comparison; Tajfel, 1982) and an early expansion of the behavioral impact of balance as it is expected to be related to perceptions of overall similarity between individuals (Broxton, 1963; Davis, 1963). For example, the relationships of the four node, Romeo and Juliet network can be conceptualized with an additional type of relationship. If, one were to assume that the disdain between the Capulets and Montegues is due to an unpaid debt, the network would contain 'owes money to', 'is a member of', and 'like/dislike' relationships together in the same balance graph.

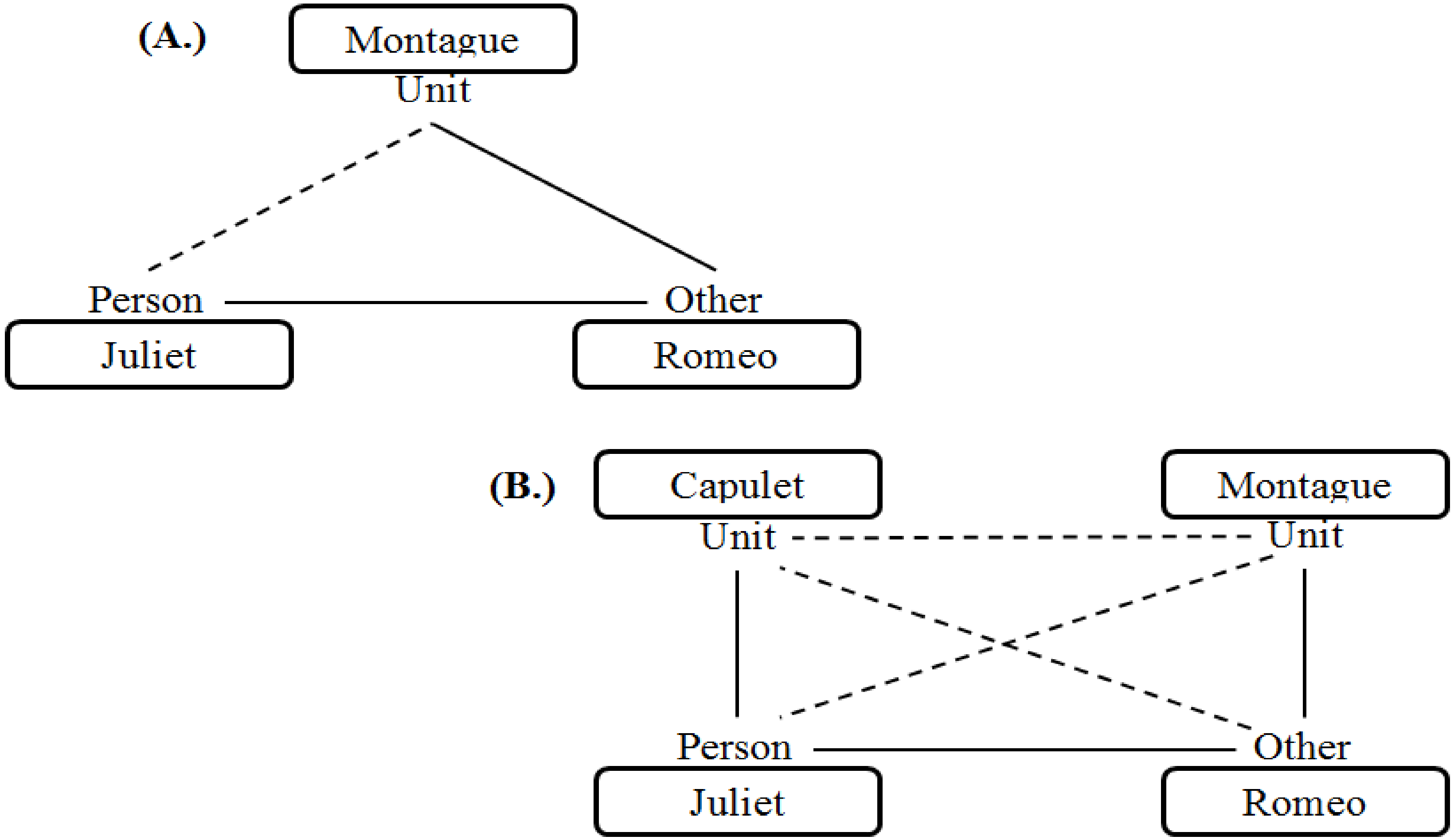

Figure 2: Example of a Person-Other-Unit balance graph and a Person-Unit-Other-Unit balance graph adapted from Davis (1963)

Note: Solid lines indicate a positive path and dashed lines indicate a negative path.

Balance Theory Determinants of Structural Alignment

Applied to the topic of this thesis, the concept of balance exists in the structural alignment between the co-occurrence of the process and states of interest (i.e., advice-communication and hindrance-communication) within each dyad. As each dyad strives towards balance between each pair of phenomena, it will do so by either tending towards structural alignment or contra-alignment. That is, each individual's personal balance graph with every other individual will develop based on their own idiosyncratic method of controlling for the presence of the cognitive and affective states. To the extent that individuals within each collective tend towards greater alignment or contra-alignment, states and processes will emerge with substantively different structural properties.

Extending the logic of Cartwright and Haray (1956) and Davis (1963) the graph which will best capture the balance (or imbalance) of each dyadic relationship including both a state and a process would include four nodes (the sender and receiver that make-up the dyad, the state, and the process) with six edges (one for each possible pair of nodes). Figure 3 displays two hypothetical graphs for a single dyad indicating (a) balance between advice and communication and (b) balance between hindrance and communication. Table 1 provides further detail on the theoretical meaning of each edge which will be revisited throughout the remaining hypotheses. The edge between the two actors (Sender and Receiver) is relational (e.g., like/dislike) while the other five paths between are unit relationships (e.g., associated with/not associated with).

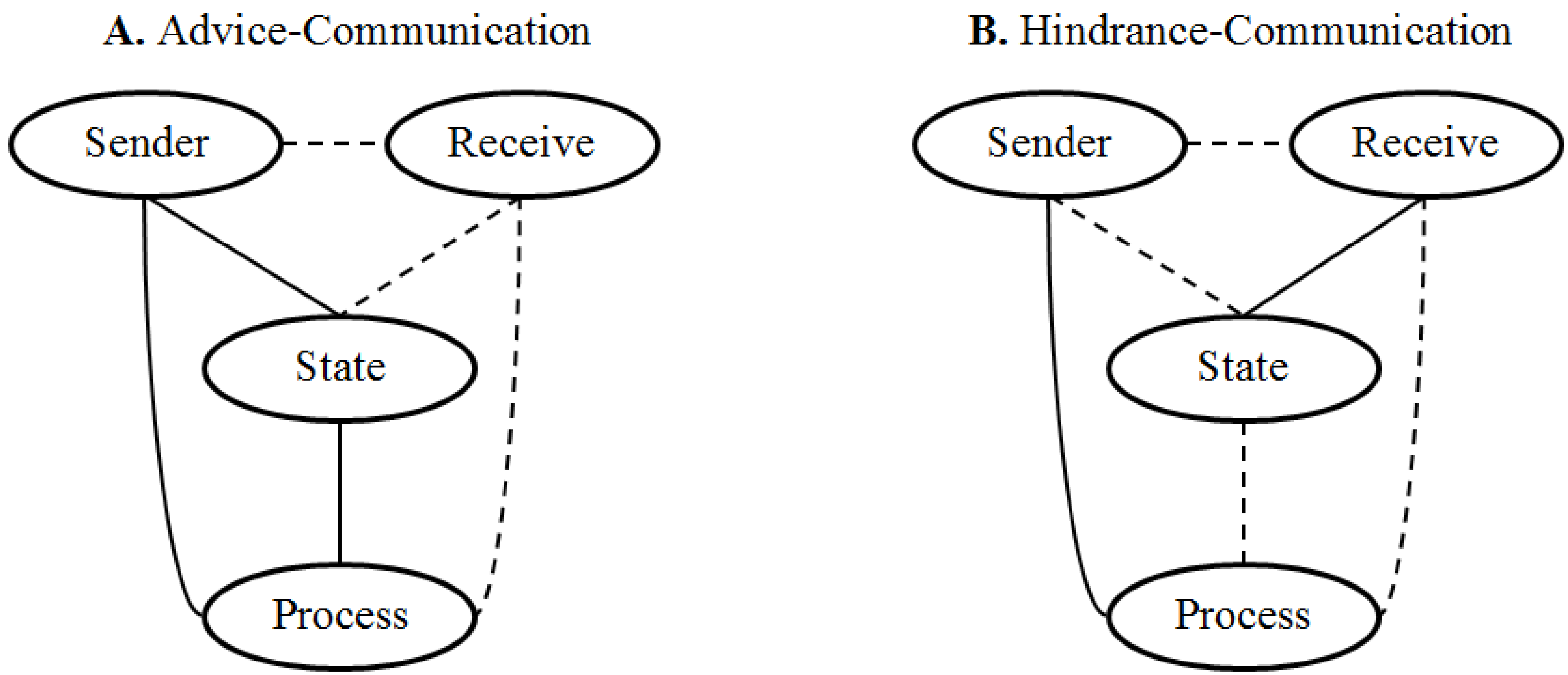

Figure 3: Illustrative example of balanced four-point graphs consistent with the phenomena of interest: Advice and Hindrance as states and Communication as process.

Note: Solid lines indicate a positive path and dashed lines indicate a negative path.

Table 1: Definition of the paths within the balance graphs.

Path	Definition	Positive	Negative
Sender—Receiver	The direct relationship between the Sender and the Receiver.	The Sender wants to associate with the Receiver.	The Sender does not want to associate with the Receiver.
Sender—Process	The expression of the Process by the Sender.	The Sender engages in the Process (e.g., communication).	The Sender does not engage in the Process (e.g., communication).
Sender—State	The valence of the State as a value of the Sender.	The Sender values a state (e.g., advice).	The sender values the absence of a state (e.g., hindrance).
Receiver—State	The Sender's perception of the association between the Receiver and the State.	The Receiver is perceived as imbued with the State.	The Receiver is perceived as having an absence of the State.
Process—State	The Sender's expectation of the association of the Process with the State.	The Process will be imbued with the State (e.g., communication will yield advice OR communication will yield hindrance).	The Process will result in an absence of the State (e.g., communication will yield a lack of advice OR communication will yield a lack of hindrance).
Process—Receiver	The Sender's perceived self-consistency of the expression (or lack thereof) of the Process given the direct relationship with the Receiver.	The Sender perceives self-consistency between their behavior and their relationship with the Receiver (e.g., communicating with a preferred Receiver, not communicating with a non-preferred Receiver).	The Sender perceives self-consistency between their behavior and their relationship with the Receiver (e.g., not communicating with a preferred Receiver OR communicating with a non-preferred Receiver).

Additionally, the structure of the graph is conceptualized in terms of the perceptions of the Sender which both reduces complexity and more appropriately captures the subjective nature of balance as a cognitive process (Heider, 1944; Peeters, 1971; Casciaro, 1998). As the sender must assess the valence of unknown relationships based on the understanding of the known relationships, there is a tendency towards inferring the existence of balanced sets of relationships, rather than imbalanced sets (Wyer & Lyon, 1970). With this, there are two considerations driving the expected effects due to the principles of balance theory: 1) Can the graph be balanced? And, 2) what is the nature of the balanced relationships (i.e., the distribution of positive and negative paths)? The answers to these two questions are expected to vary across the combinations of states, behavioral processes, and levels of interest. These answers drive the hypothesized moderating effects of structural alignment on the direct relationship between communication and performance across these states and levels.

Structural Alignment as a Moderator of Process on Performance

Structural alignment between two individuals, a state, and a process (Figure 3) may be understood in terms of the Sender—Process and Receiver—State paths shown. The Sender—Process path indicates the association of the Sender with the Process; that is, the tendency of the Sender to engage in communication with the Receiver. The Receiver—State path indicates the perceived association of the Receiver with the State; that is, the extent to which the Sender perceives the Receiver as being associated with the existence of a given state. Within the interests of this thesis, this path indicates a potential association with either providing information (advice) or difficulties (hindrance). By definition, structural alignment will occur when both the Sender—Process and

Receiver—State paths are positive or when both are negative. Conversely, structural contra-alignment will occur when these paths have opposite signs (i.e., one path is negative and the other is positive). It is important to note that structural contra-alignment does not *necessarily* indicate imbalance across the entire graph.

Balance in the Structural Alignment between Process and Cognitive State

As one engages in communication it may be directed towards those individuals which have knowledge or those that do not. Structural alignment between communication and advice relationships indicate a tendency to direct communication towards individuals whom one perceives as having valuable information. The opposite case, structural contra-alignment, indicates a tendency towards communicating with those who are perceived as lacking valuable information. Communication in these two cases may capture behavioral processes having fundamentally different impacts on performance at both the team and MTS levels. Communication originating from individuals that have information towards those that do not are essential in establishing and maintaining the necessary conditions for high quality collective states (Fiore & Salas, 2004). With this, the effect of communication on performance has been shown to be enhanced to the extent that it allows information to flow through the collective (Mathieu, et al., 2000; Kanawattanachai & Yoo, 2007).

These findings indicate the need for communication to be actively directed towards those individuals that require information. With this, the expected positive direct relationship between within-team communication amount and team performance may be nullified when there is a tendency to communicate only with those who are perceived as having information. Conversely, the expected within-team communication to performance relationship may be enhanced when there is a tendency to communicate with those who are perceived as not having valuable information. These two tendencies illustrate the cases of structural alignment and structural contra-alignment between communication and cognitive state, respectively.

Conceptualizing Balance Mechanisms in Structural Alignment

In terms of the balance graphs, both structural alignment and contra-alignment are balanceable states (see Figure 4), but their patterns are quite different. Figures 4a and 4b show the two contra-aligned graphs while 4c and 4d show the two aligned graphs. Together, these four balance graphs indicate that, irrespective of the overall alignment or contra-alignment, Senders prefer Receivers (Sender—Receiver edge) that are perceived to have more valuable information (i.e., positive association with advice; Receiver—State edge). This is a purely logical conclusion as possessing useful knowledge is presumed to be a positive association of the Sender (Sender—State edge). That is, senders will always prefer relationships with those receivers perceived to have valuable information. However, it does not mean that all senders will focus all or most of their behavior towards these preferred receivers

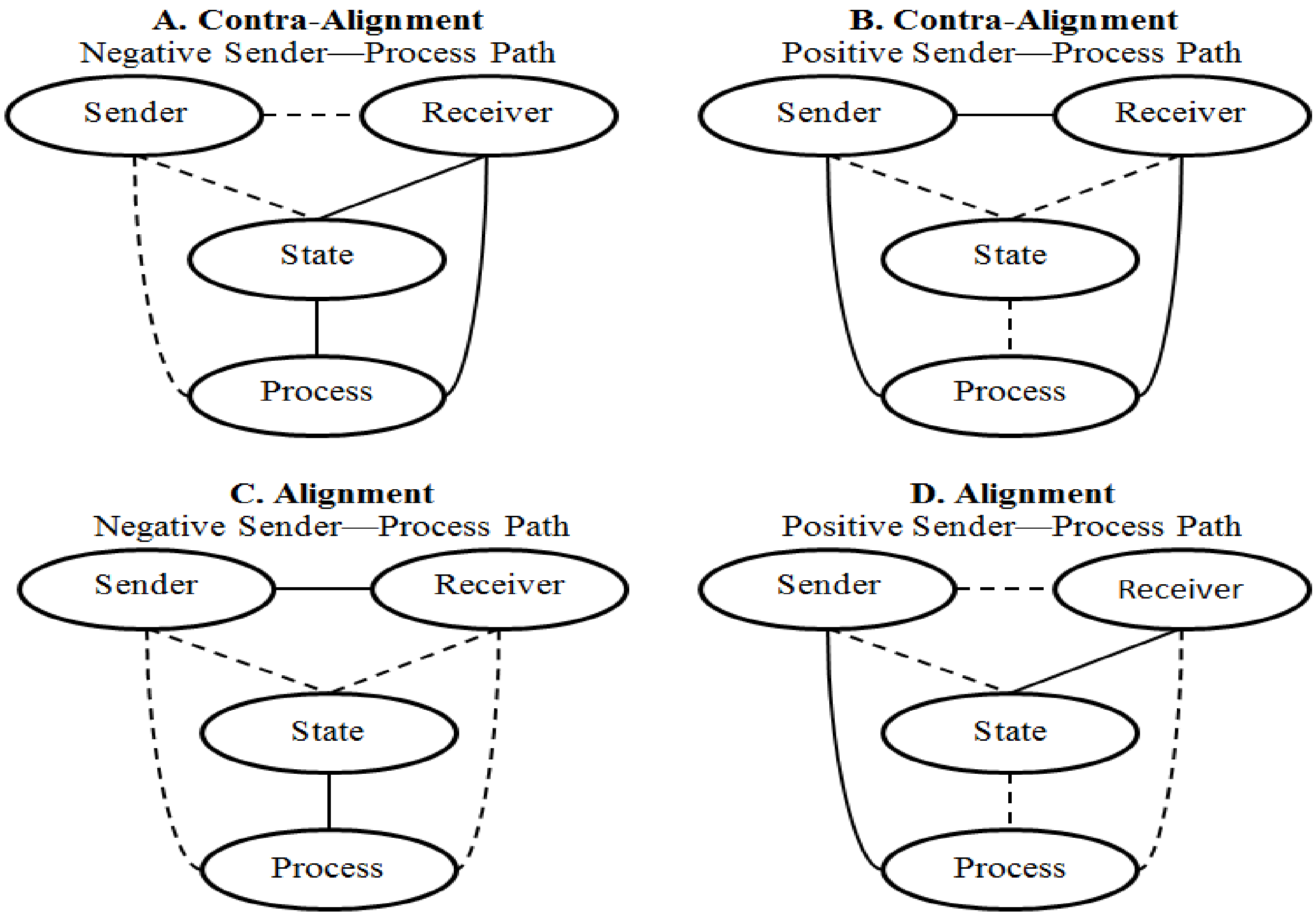

Figure 4: Balanced graphs indicating either structural alignment (C & D) or contra-alignment (A & B) between communication (Process) and advice (State) when communication is either expected to occur (B & D) or not occur (A & C).

Note: Solid lines indicate positive paths and dashed lines indicate negative paths.

The value of the edges in the aligned (Figure 4c & 4d) and contra-aligned (Figure 4a & 4b) balance graphs diverge in terms of the structurally dependent Process—State and Process—Receiver edges. Implicitly, the Process—State edge simply indicates the extent to which communication is believed to be associated with valuable information determined by the values of the Sender—Receiver, Sender—Process, Sender—State, and Receiver—State edges. These four edges create two independent multistep paths known as cycles. To determine the balanced value of the Process—State edge, the State—Sender—Process and Sender—Process—State—Receiver cycles must be considered (Cartwright & Haray, 1956). These two cycles must be balanced so that the Process—State edge has the same value within both cycles.

First, the State—Sender—Process cycle indicates the association that the Sender perceives to exist between communication and information (Process—State edge) in terms of his personal value of information (Sender—State edge) and the association between himself and communication (Sender—State edge). Communicating is always perceived to be more associated with information than not communicating. Therefore, the values of all three edges in this cycle are positive.

Second, Sender—Process—State—Receiver cycle captures the perceived value of communicating with a Receiver conditional on the Receiver's association with the given State. That is, does the Sender perceive value in communicating with Receivers that either do or do not have valuable information themselves? For the contra-aligned graphs, this cycle indicates the perception that communication is considered valuable when the Receiver is perceived to lack valuable information (Receiver—State edge). Conversely, the same cycle in the aligned graphs indicates that communication is considered valuable when the Receiver is perceived to have valuable information already.

This type of explanation of varied associations between two phenomena based on the pattern of relationships between a sender and receiver has been theorized previously. Anderson (1971) conceptualized attitude change in terms of these types of associations within an analogous two person, two phenomena balance graph. Though viewed from the perspective of the receiver, it was postulated that changes in the values of individual edges within the cycles of a balanced graph were able to capture perceptions of the phenomena occurring between the individuals. However, because the focus was on the receiver, rather than sender, this conceptualization fixed the association between the sender and both phenomena. Conversely, the current conceptualization, allows the edges between the sender, state, and process to vary. For example, when the informational value of communicating is perceived to be low (negative Process—State edge), communicating behavior would tend to not occur (negative Sender—Process edge).

Balance between Behavior and Cognitive State in Teams

Lastly, the final edge (Process—Receiver) must also be balanced after accounting for the balanced value of the Process—State edge. This edge indicates the self-consistency perceived by the Sender such that a positive edge indicates consistency and a negative edge indicates inconsistency. Consistency as defined in terms of actions towards others postulates that individuals will strive to act in a way that matches their internal state (Jones, 1973; Festinger, 1957). The Process—Receiver edge captures consistency because it is determined by the Sender—Process—Receiver cycle. As aforementioned, the Sender—Process edge indicates the Sender's tendency to engage in communication and the Sender—Receiver edge captures the relationship between the Sender and

Receiver. Therefore, when these two paths have opposite values, the Sender is either not communicating with a receiver with whom he has a positive relationship or is communicating with a Receiver with whom he has a negative relationship. Such a situation is indicative of inconsistency between displayed actions and one's internal state while the opposite (i.e., these two paths are both positive or both negative) would indicate consistency.

Consistency can be seen in the two aligned graphs (Figures 4c & 4d) such that when the Sender—Receiver and Sender—Process edges are either both positive or both negative, the Process—Receiver edges are positive. Conversely, inconsistency can be seen in the contra-aligned graphs as the Process—Receiver edges are negative due to either the Sender attending to a negative relationship or ignoring a positive relationship. As balance and self-consistency theories would suggest, such a structure to be unlikely to emerge spontaneously, higher-level motivating factors are likely playing a role.

With this, balance must also be considered as it occurs in the relationships between individuals across the entire collective. At the team level, the shared unit relation common to all individuals is team membership. At this level, the relationships across an entire team can be considered to be either balanced or unbalanced. Specifically, an unbalanced situation occurs when there exists a positive unit relation with the team (i.e., the individual recognizes his team membership) and at least one negative relationship with any given member of the team (Davis, 1963; Hummon & Doreian, 2003). While perfect balance is unlikely to ever be achieved across any sufficiently large team, individuals are still expected to strive towards more balanced configurations. This can be done in one of two ways: 1) remove the negatively related others from the shared team association or 2) remove the negative relationship from the other and thus merit the shared team association (Davis, 1963). The former would result in a tendency towards not communicating with those others with whom one holds a negative relationship in order to cognitively separate they from the team. This balancing mechanism would result in structural alignment between communication and advice. Conversely, the latter would result in a tendency towards communicating with those same others in order to improve their deficits in knowledge. This balancing mechanism would result in structural contra-alignment between communication and advice.

As aforementioned, traditional research on teams has shown support for positive relationships with performance due to integrating behaviors explicated in the latter balancing mechanism. Though scant, recent research from the network perspective has provided additional support for the presence of such mechanisms in teams (see Zhong, Huang, Davison, Yang, & Chen, 2012). Altogether, there is significant evidence for the potential impact of structural alignment on communication and cognitive states within teams. With this, it is expected that structural contra-alignment between communication and advice relationships, that is a tendency towards communicating with those who lack information, will strengthen the positive impact of communication on team performance while structural alignment will weaken the same (see Figure 5a). Thus, it is hypothesized that:

Hypothesis 4: (a) The effects of intra-team communication network density on team performance will be moderated by the structural alignment between the intra-team communication and advice relationships such that when there is structural ***contra-alignment*** *between the two, communication will be more* *positively related to team performance than when there is* ***structural alignment****.*

Balance between Behavior and Cognitive State in Multiteam Systems

The development of high quality cognitive states is expected to be similarly important for MTS functioning as it is to team functioning (Mathieu, et al., 2001). The nature of interdependence within MTSs may change the mechanisms through which cognitive states influence the effectiveness of communications. Specifically, there is expected to be weaker interdependence between individuals in different component teams which has been shown to moderate the role of cognitive states (Gladstein, 1984; Saavedra, Earley, & Van Dyne, 1993). The component teams within an MTS share an environment and require a certain amount of information exchange, but this does not necessitate the same degree of overlap in knowledge or understanding as is theorized to be beneficial within teams (Davison, Hollenbeck, Barns, Sleesman, & Ilgen, 2012).

Rather than benefitting from greater shared knowledge or universal understanding, it is more important for each team to simply know how they fit with each other team and the MTS as a whole. Evidence for the relative importance of this type of cognitive state existing between interdependent teams can be most clearly derived from research done on boundary spanning behaviors. Boundary spanning has been shown to be essential in both bringing necessary resources to the team and in buffering the team from unnecessary demands (Marrone, 2010). These types of behaviors are specifically oriented towards entities existing outside of the boundary of the team. Analogous to these behaviors is the aforementioned behavioral process of inter-team communication which captures the communication occurring between two individuals of different teams within an MTS.

In order to fulfill the two core benefits of boundary spanning behaviors (acquiring resources and buffering external demands) inter-team communication would benefit from structural alignment with cognitive state. Directing communication towards knowledgeable members of other teams has a greater likelihood of providing necessary informational resources. Conversely, directing communication towards members of other teams that lack knowledge has a greater likelihood of resulting in unnecessary demands and no additional resources (Ancona & Caldwell, 1992). Therefore, the same balance mechanisms that are functional at the team level, may lead to dysfunctional outcomes at the MTS level as strong inter-team associations can be expected to be less critical in and of themselves (Crawford & LePine, 2013).

With this, it is expected that structural alignment between communication and advice relationships will strengthen the expected positive impact of communication on MTS performance while structural contra-alignment will weaken the expected positive relationship (see Figure 5b). That is, high levels of inter-team communication will be most beneficial to performance when directed at those others who have information. Thus, it is hypothesized that:

> *Hypothesis 4: (b) The effects of inter-team communication network density on MTS performance will be moderated by the structural alignment between the inter-team communication and advice relationships such that when there is* ***alignment*** *between the two, communication will be more strongly related to MTS performance than when there is* ***contra-alignment.***

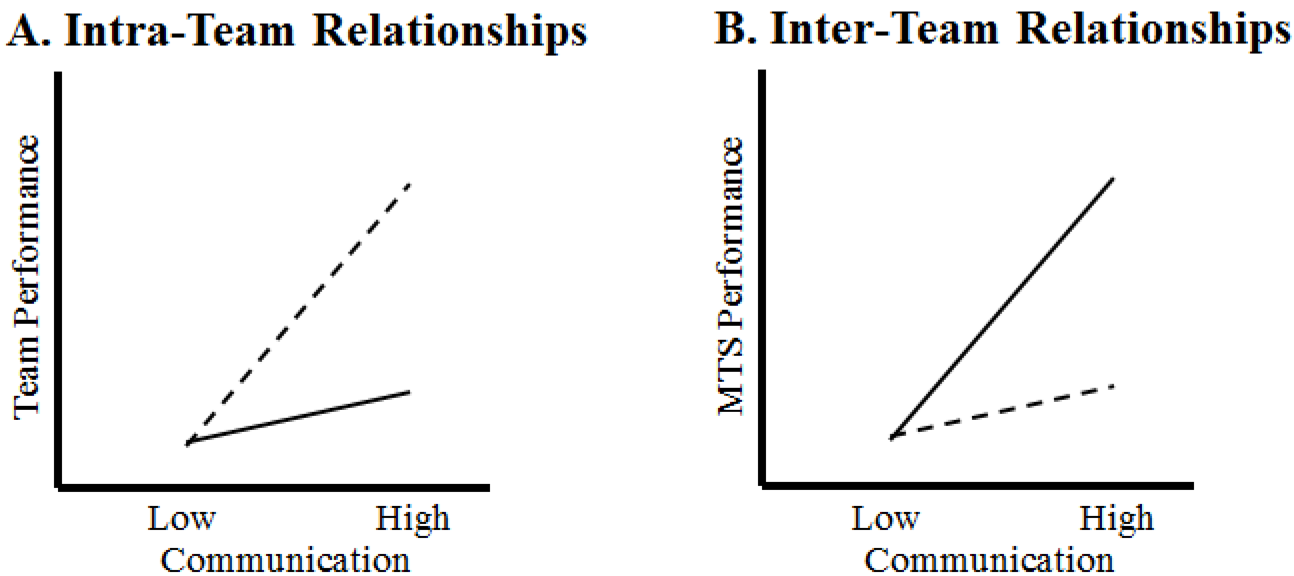

Figure 5: Hypothesized interaction effects between communication amount and advice-communication structural alignment in predicting collective performance (Hypothesis 4).

Note: Solid lines indicate structural alignment while dashed lines indicate structural contra-alignment.

Balance in the Structural Alignment of Communication and Affective State

In addition to the moderating effect of cognitive states, the affective state arising from the hindrance relationships within the team and MTS are also expected to have a moderate the relationship between communication and performance. Hindrance as an affective state indicates the presence of dysfunctional relationships between individuals. Structural alignment between hindrance relationships and communication are expected to result in less positive impacts on collective performance while contra-alignment will result in greater positive impacts. Additionally, it is possible that structural alignment will not only weaken expected positive relationships, but potentially reverse them to become negative. As aforementioned, affective states have been theorized and shown to impact both the specific behavioral processes displayed and how these behaviors are understood by the collective. Specific to communication and hindrance relationships, the amount of communication and its value are both expected to be decreased to the extent that hindrance is common (Menon & Blount, 2003). These relationships have been conceptualized as the messenger bias wherein communication tendency and valuation is impacted by the strength and valence of the affective relationships existing between the sender and receiver.

In terms of balance theory, these biases evidence changes in the interpretation of what behaviors may be considered positive in order to maintain balance with the extant perception of the sender to receiver relationship. That is, when a negative relationship exists, any communication is more likely to be perceived as negative by both the Sender and the Receiver. Conversely, when a positive relationship exists, subsequent communication is more likely to also be perceived as positive. In terms of structural alignment between hindrance and communication relationships, only the tendency of co-occurrence can be considered initially. Structural alignment is observed when there is a tendency towards communicating with those one perceives as engaging in dysfunctional behaviors. Conversely, contra-alignment would be observed as a tendency towards communicating with those one perceives as not engaging in dysfunctional behaviors. It is important to note that structural alignment/contra-alignment is not synonymous with self-consistency when considering negatively valenced relationships such as hindrance.

That is, structural alignment, in and of itself, merely captures the extent to which two phenomena (in this case the negative affective state hindrance and the process of communication) are observed to co-occur. However, self-consistency can still be considered within the aforementioned four node balance graph. The effect of the negative value of hindrance as an affective state is captured in the balance graph as a negative edge between Sender and State. Figures 6a and 6b show the two contra-aligned graphs while 5c and 5d show the two aligned graphs. Together, these four graphs indicate that, irrespective of the overall alignment or contra-alignment, Senders prefer Receivers (Sender—Receiver edge) that are perceived to not engage in dysfunctional behaviors (i.e., negative association with hindrance; Receiver—State edge). Though not wholly dissimilar from the advice-communication balance graphs shown in Figure 4, there are important distinctions that must be made about the structures and meanings of these graphs. Primarily, a negative association between Sender and State will result in contra-aligned graphs having self-consistency (positive Process—Receiver edges) and aligned graphs lacking self-consistency (negative Process—Receiver edges). Second, the meaning of the Process—State edge remains the same as previous discussed, but must be understood in context with the presumed valence of the state.

Balance between Behavior and Affective State in Teams

When State represented advice relationships, a positive edge indicated similarly positively valenced process. However, now the State represents hindrance relationships, a similar positive path between Process and State would indicate dysfunction and, thus, be negatively valenced. The State—Sender—Process cycle indicates the Sender's valuation of communication in terms of the negative valenced hindrance relationships. Thus, not communicating is always more closely associated with dysfunction than communicating. The Sender—Process—State—Receiver cycle indicates the extent to which communication is expected to be functional when the Receiver is either perceived as causing hindrance or not. The aligned graphs indicate that communication is associated with dysfunction when the Receiver is not perceived as engaging in dysfunctional behaviors (Figures 6c & 6d). Conversely, the contra-aligned graphs indicate that communication is associated with dysfunction when the Receiver is perceived as engaging in dysfunctional behaviors (Figures 6a & 6b). Though these relationships may seem counter-intuitive, their meaning is likely fairly simple. The former is indicative of a conflict management perspective wherein a tendency to focus communication on those engaging in dysfunctional behaviors will lead to resolution. The latter, however, is indicates a tendency to utilize the path of least resistance and thus avoid dysfunction altogether. As aforementioned, in the case of hindrance relationships, structural contra-alignment indicates self-consistency and structural alignment indicates inconsistency.

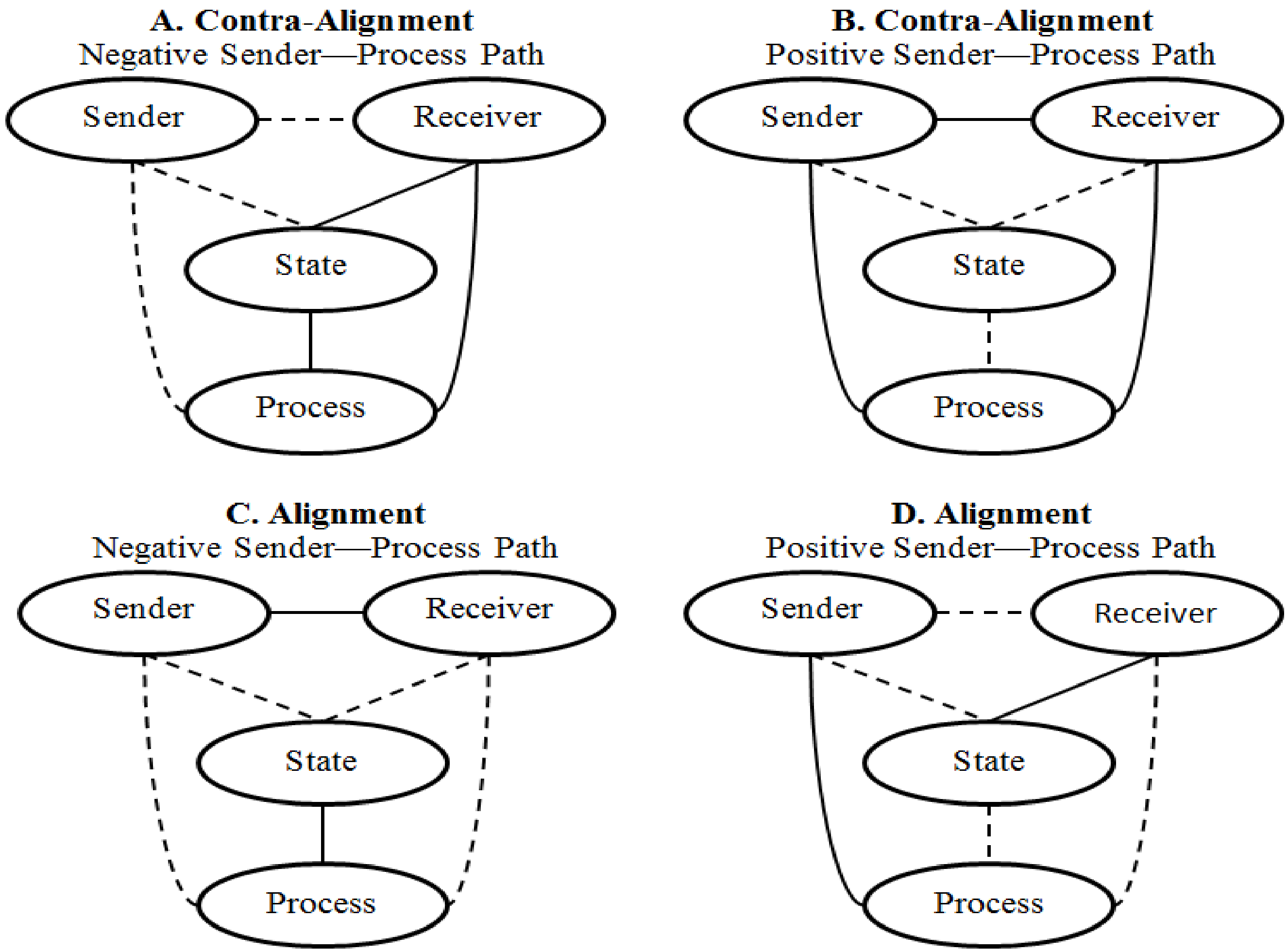

Figure 6: Balanced graphs indicating either structural alignment (C & D) or contra-alignment (A & B) between communication (Process) and hindrance (State) when communication is either expected to occur (B & D) or not occur (A & C).

Note: Solid lines indicate positive paths and dashed lines indicate negative paths.

Balance itself was believed to be the more important factor when considering a cognitive state as balance theory itself is cognitive in nature. However, the same cannot necessarily be said when the focus is an affective state. Previous research has shown that self-consistency and self-determination are critical considerations for understanding the impact of affective states on interpersonal processes (Staw & Kramer, 2003). Individuals may attribute one of three affective roles to another depending on whether positive, passively negative, or actively negative relationships exist. Importantly, hindrance relationships are conceptualized in terms as both active and passive negative relationships. Communication tendencies between each member will be influenced by the extent to which one's affective evaluation expects such a behavior to maintain positive affect, enhance the group, and fulfills desires for self-determination and self-consistency (Menon & Blount, 2003; Deci & Ryan, 2000).

In this case, self-determination is of particular importance as it encapsulates the "innate psychological needs for competence, relatedness, and autonomy" (Deci & Ryan, 2000, p. 229) of individuals as they relate to one another in a collective. Individuals will generally not choose to interact with others that do not support the fulfillment of these needs. With this, the presence of a hindrance relationship will be expected to result in a lower tendency for communication. However, certain interdependencies may require an individual to continue to interact with another despite this influence. These compulsive communications will likely result in perceptions of lower self-determination and, in turn, impact the relationship between communication and performance. For instance, an individual's perception of their own autonomy will be threatened to the extent that they feel they are obligated to interact with another with whom they do not want to (Langfred, 2007). Thus, the individual may communicate with different language, provide less information, or change contextual cues simply to reinforce their own perception of their autonomy. Such changes are expected because of the strong need to maintain self-consistency between affect and behavior (Festinger, 1957; Bem, 1967). Therefore, secondary processes are likely to result in a Sender having different perceptions of the State—Process and Process—Receiver edges than would be expected from the application of balance theory.

Maintenance of self-consistency is expected to be a strong mechanism driving the moderation between communication and affective states. Communication is expected to be dysfunctional to the extent that the Receiver is perceived as having engaging in a hindrance relationship. Therefore, a given Sender's self-consistency will be maintained by ignoring those Receivers perceived as engaging in hindrance relationships. In circumstances that do not allow such self-determination, behaviors will be altered to fit the Sender's perception of the dysfunction of the Receiver in order to restore a semblance of self-consistency. This expectation is supported by consistent findings of greater amounts of behavioral processes between individuals with high negative affect shown to harm performance (e.g., Jehn & Mannix; 2001; Lira, Ripoll, Peiro, & Gonzalez, 2007; Bradley, Postlehwaite, Klotz, Hamdani, & Brown, 2012). Thus, it is expected that structural alignment between communication and hindrance relationships, that is a tendency towards communicating with those who one has a negative affective evaluation, will cause the expected positive impact of communication on team performance to become negative (see Figure 7a). Thus, it is hypothesized that:

Hypothesis 5: (a) The effects of intra-team communication network density on *team performance will be moderated by the structural alignment between the intra-team communication and hindrance network structures such that when there is* ***alignment*** *between the two, communication will be negatively related to team performance while* ***contra-alignment*** *will yield a positive relationship.*

Balance between Behavior and Affective State in Multiteam Systems

Mechanisms homologous to those that occur within teams can also be expected to occur between teams within an MTS as well. However, the exact nature of these mechanisms varies depending on the group membership status of the Sender and Receiver. In addition to the aforementioned in-group relationships, Menon and Blount (2003) theorize the existence of affective roles and corresponding effects attributable to individuals who are members of some out-group (e.g., the Sender and Receiver are on different teams). Once again the tendency for communication as well as the specific behaviors expressed is expected to be influenced by the strength and valence of the affective roles attributed to each individual. When looking at between-team interactions, the exact influences are different than when focused on within-team interactions. Specifically, individuals focus more on obtaining useful and valuable resources, maintaining their own team's status, and reducing cost.

Therefore, communication can be expected to occur more frequently towards those individuals that are believed to be willing to provide resources, are unlikely to undermine the status of the group, and unlikely to require further resources/obligations. The dysfunctional complements of these desirable behaviors map closely onto those that are expected to be captured by hindrance relationships (e.g., uncooperativeness, sabotage, & unrealistic demands; Contractor & Monge, 2003). Because of lower levels of interdependence between teams than within, there are fewer opportunities for compulsory communications to occur. Thus, communication that occurs between individuals that also have stronger negative affective relationships are likely to still be internally motivated. This yields a weaker expected impact of violations of self-determination because these paradoxical interactions are less likely to threaten one's perceived autonomy and, in turn, self-consistency. Therefore, the modification of behaviors that would be intended to reinforce self-consistency are weaker than what is expected in teams. With this, the moderation of the relationship between communication and performance at the MTS level is expected to be less extreme than that which is expected in teams.

The effect on the impact of these behavioral processes on performance due to affective states is expected to be driven by the expected value of the interaction shaded by the hindrance relationship (Menon & Blount, 2003). With this, the impact of balance mechanisms, rather than self-consistency, can be expected to explain the relationship with structural alignment. Consequently, the moderating effects of structural alignment are expected to be weaker than what is observed within teams. Unlike within teams, the between-team mechanisms are not expected to change the sign of the expected positive direct relationship between communication and performance. With this, it is expected that structural alignment between communication and hindrance relationships will weaken the positive impact of communication on MTS performance. That is, a tendency towards not communicating with those who one has a negative affective evaluation will result in the strongest relationships between communication and MTS performance (see Figure 7b). Thus, it is hypothesized that:

Hypothesis 5: (b) The effects of inter-team communication network density on

MTS performance will be moderated by the structural alignment between the inter-team communication and hindrance relationships such that when there is ***alignment*** *between the two, communication will be less strongly related to MTS performance than when there is* ***contra-alignment****.*

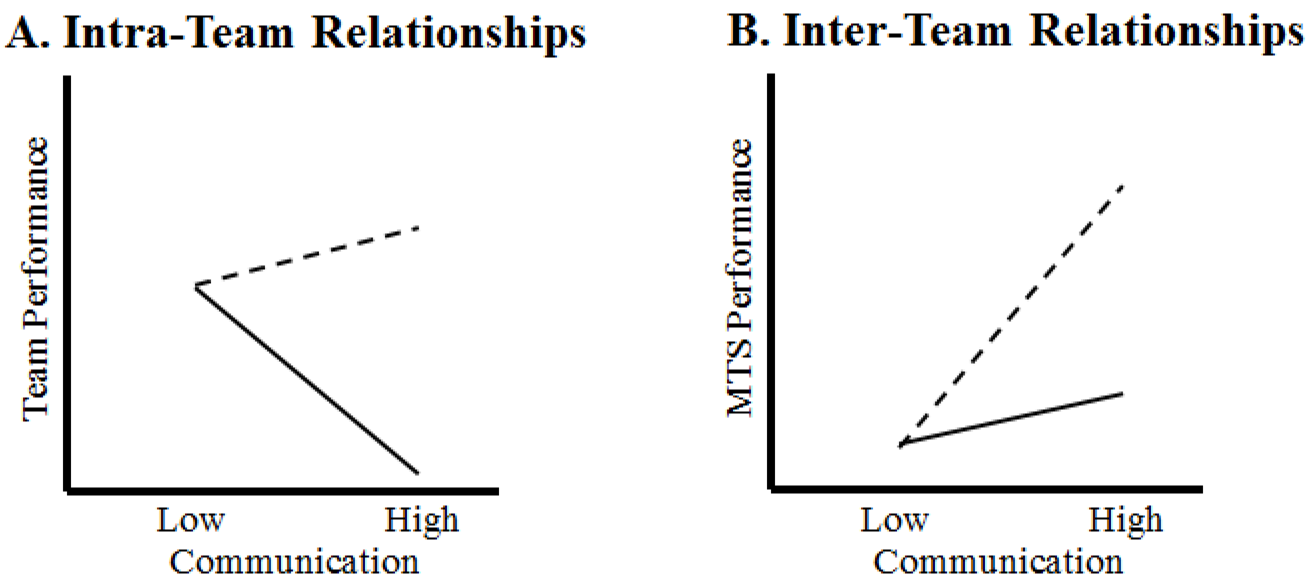

Figure 7: Hypothesized interaction effects between communication amount and hindrance-communication structural alignment in predicting collective performance (Hypothesis 5).

Note: Solid lines indicate structural alignment while dashed lines indicate structural contra-alignment.

CHAPTER 2

METHOD

Participants & Design

Participants included 708 undergraduate psychology students from a large southeastern university. Participants formed 118, 6-person MTSs, each MTS was tested in a separate session. A version of the Simulation Utilizing Real-time strategy in the Research of Effective Alliances, Leaders, and Information Sharing in Multiteam systems (SURREALISM) was used to model an MTS comprised of two 3-person hierarchical teams with a single formal leader and two subordinate team members. Leaders were formally responsible for coordinating the work of their own subordinates and had the ability to manage access to information. Additionally, they had a more comprehensive understanding of the component teams' interdependencies within the MTS. Subordinate team members interacted directly with the environment by locating new information and engaging enemy units. Though the leaders were uniquely positioned to act effectively both intra- and inter-team, all MTS members were able to coordinate with any other.

The superordinate goal of the MTS was to safely guide an unarmed convoy of supply trucks through a hostile area. In order for the MTS to accomplish this goal, the two component teams needed to gather and interpret information ('intel') from the mission environment and neutralize hostile forces. The information that was gathered was required for the teams to accurately determine the best route for the convoy to travel. Each piece of intel obtained by the MTS, provided new information on the location of enemies which may attack the convoy. Once both leaders agreed that an area on the preprogrammed path to be followed by the convoy was safe, an automated order was sent to the convoy forcing it to move to its next position. In each mission, the convoy followed a path of equal length that required the same amount of intel to be interpreted and number of enemies to be neutralized to be completed. These activities required the interpreting of two types of intel and the neutralization of four classes of enemies. To ensure interdependence, each team could interpret only one type of intel and neutralize only two of the four classes of enemies, whereas intel was equally important to both teams and three classes of enemies were threatening to each team. Thus it was not possible for one team to perform the MTSs tasks working alone.

The teams were located in two separate rooms and were positioned so that when performing the tasks, they could only view the simulation activity depicted on their monitor. The component team leaders interpreted and relayed intel gathered during the task back to the team through the designation of battlefield zones. Depending on information obtained, leaders could zone an area as restricted (indicating the existence of a threat that should not be neutralized), engagement (indicating the existence of a threat that should be neutralized), and safe (indicating a lack of threats). Leaders were able to see the movements of all four subordinate controlled units and the convoy's movement on the battlefield, an interactive strategic map allowing for the setting of zoning designations, as well as all intel that has been transmitted to them by either of their subordinates.

Each team's subordinate team members interacted with the battlefield independently by commanding a specific type of unit. Each unit type was able to neutralize only one class of enemy unit and was attacked by either one or two classes of enemies, depending on the unit type. Additionally, every unit was able to gather any intel available on the battlefield. Intel could be automatically communicated to their team's leader if it was interpretable by their team. Lastly, common team subordinates were highly interdependent as either type of unit was vulnerable to a class of enemy that only their team member would be able to neutralize. If a team member's unit was destroyed, reinforcements could be requested after a short time delay and were placed at the starting point of the mission.

All six MTS members could freely communicate with all other MTS members via microphone-equipped headsets. Communication channels were created allowing participants to choose precisely to whom they would like to speak. Also, team leaders were able to alert their subordinates with any piece of intel felt to be relevant by automatically displaying it on a specific area on their interface. Additionally, the zoning designations made by each team leader were automatically displayed on their subordinates' interfaces. However, this information was not provided to the leader or subordinates on the other team.

Procedure

Each MTS was tested in a separate 4.5 to 5-hour session that commenced in three general phases: introduction, training, and task engagement. In the introduction phase, participants provided informed consent, completed a battery of measures, and were introduced to the task they would be completing. Team assignments were then made by selecting the leaders whose scores on the personality measures were most closely balanced to indicate leadership success (Judge, Bono, Ilies, & Gerhardt, 2002) and then all subordinate roles were randomly assigned to the remaining participants.

Each team member was first trained independently on their role specific duties before being brought together to practice working as a unit. All six team members received task training through an automated training guide and then allowed to practice further in a training mission with guidance from a trained experimenter. These processes assured that all participants were clear on the tasks and goals of the missions, the particulars of their role, and their ability to control the interface. The subordinates required more training in interacting with the battlefield as much more of their task was involved at that level, whereas much more of the leaders' duties were related to information sharing and coordination. To accommodate this, an additional 20 minutes was added to the time subordinates performed during the training mission while the leaders were provided more detailed information regarding their subordinate team members and potential strategies to be used during the missions to allow for better coordinating. Training effectiveness was assessed by the behaviors observed by the experimenter and a brief, but comprehensive questionnaire assuring each participant retained the necessary knowledge.

The task engagement phase of the experiment began with a short briefing from the "MTS commander" (pre-recorded video) which provided the participants with important information regarding the environment and their goals for the mission. After the briefing, the two teams were separated and give 5 minutes to come up with an action plan for the mission. The teams then reconvened and worked together for an additional 5 minutes to communicate and further develop their plan for the mission. Once the transition phase activities ended, the MTS had 30 minutes to complete the mission as extensively as possible. The objective measures of performance and communication were assessed as the mission progressed while the perceptual measures were given immediately after the mission had ended.

Objective Measures

MTS Performance

MTS performance is the extent to which the highest level of collective goal is reached. As an example, an MTS comprised of a firefighting team, an EMT team, a surgical team, and a recovery team, would have a relevant index of MTS performance as patient's survival or lives saved (Mathieu et al., 2001). In the current simulation, MTSs were instructed to escort a convoy of unarmed supply vehicles through a hostile area. Fulfillment of this goal required the completion of all tasks and team goals, as well as additional inter-team coordination. MTS performance was operationalized as the distance traveled in meters by the convoy and ranged between 0 and 1590. This measure was developed to capture the goal attainment of the MTS, as opposed to just aggregating an index of component team performance (e.g., summing the number of authorized enemies destroyed). The interdependence among component teams is a defining aspect of a multi-team system, and so MTS level performance measures need to identify the collective goal and quantify the degree of goal attainment. The current study's MTSs were given the ultimate goal of escorting a convoy through a hostile area requiring the coordination of both actions and information sharing both within and across the two component teams. Neither component team's performance was found to related to MTS performance ($r = -.038$, *n.s*; $r = -.026$, *n.s*).

Team Performance

Team performance is the extent to which each of the component teams (designated SO and MI) were able to complete their respective team-level goals. As an example, take the aforementioned MTS wherein each component team would have their own relatively independent team level goals. For instance, the firefighting team may have the team goal of minimizing property damage while the EMT team's goal is to transport victims to the nearest hospital as quickly as possible. In the current simulation, each team had certain types enemies they were able to neutralize and certain types of areas they were able to "capture" and gain control. Each team's performance was assessed by combining the number of enemies neutralized properly based on the information attained and ranged from 0 to 62 with a mean of 15.1 and 12.8, respectively. Fulfillment of these goals required the coordination of team members, but not necessarily that of MTS members outside of each component team. Additionally, simply neutralizing enemies without coordinating with the rest of the MTS was unlikely to have improved MTS performance resulting in the low observed relationship between the two aforementioned.

Communication

The only method of communication for the MTS during each action phase is through a microphone equipped headset. To communicate with another member of the MTS, one must open a communication channel by pressing a button. To close the channel, the initiating member need only release the button. The member on the receiving end cannot mute the incoming communication nor can they respond back without opening a separate channel back to the initiating member. As part of this system, the amount of time that each communication channel was open is recorded. Each channel had a true minimum of zero seconds and a theoretical maximum of 1800 seconds which would denote communication on a single channel throughout the entire mission.

Observed communication scores within each dyad of these MTSs ranged from zero seconds (i.e., the communication channel between a given pair was never opened) to 1,588 seconds (i.e., the communication channel between a pair was open for 26 minutes and 28 seconds) during the 30 minute mission. These scores were used to create a separate directed, valued graph (i.e., sociomatrix) depicting all observed communications between each dyad within each of the 118 MTSs.

Perceptual/Self-Report Measures

Advice Relationships

Participants were prompted with a sociometric item which allowed them to assign an independent rating for each other person in the MTS. Each member responded to the prompt, "indicate the extent to which you went to this person for information or assistance during the simulation." They were then presented with the roles of each of the other five members of the MTS and given the ability to respond on a five point, Likert-type scale with the end points, "not at all," to, "a very great extent" (Cross, Borgatti, & Parker, 2002).

Hindrance Relationships

Participants were prompted with a sociometric item which allowed them to assign an independent rating for each other person in the MTS. Each member responded to the prompt, "indicate the extent to which this person made it difficult for you to carry out your responsibility during the simulation." They were then presented with each of the roles of the other five members of the MTS and given the ability to respond on a five point, Likert-type scale (Sparrowe, et al., 2001).

Data Analysis

Levels of Analysis

In order to test the hypotheses contained in this thesis, analyses must be conducted at two levels: the team and the multiteam system. The analyses conducted at the MTS level were simple multiple linear regressions with the MTS performance metric designated the dependent variable, the hypothesis relevant independent variables, and a consistent set of control variables which will be discussed in detail later in this section. The analyses conducted at the team level were done with hierarchical linear modeling (HLM) to account for the non-independence of teams by accounting for their shared membership in their respective multiteam systems (Bryk & Raudenbush, 1992; Klein & Kozlowski, 2000; Snijders & Bosker, 2011). Similar to the multiple regressions conducted at the MTS level, the HLM analyses included team performance as the dependent variable, the hypothesis relevant team-level independent variables, and a consistent set of control variables similar to the aforementioned. Though there are analyses being conducted at two levels of analysis, there are no hypotheses of cross-level relationships and thus all HLM analyses focus only on the effects of variables at the team level. However, the set of control variables exist at the MTS level.

Network Indices

The hypotheses were assessed by analyzing the MTS communication, advice, and hindrance networks. These three types of indicate behavioral process (i.e., observational data on who communicates with whom), a cognitive state (i.e., who views whom as a valuable source of information or assistance), and an affective state (i.e., who views whom as detracting from their ability to function).

Hypotheses one through three were tested by regressing team- and MTS-level performance on the densities of each of the three measured network relationships (communication, advice, and hindrance). Density is calculated by comparing the sum of the observed relationships with a theoretical maximum for the network. This is a simple calculation for the advice and hindrance networks because their measurement on a 5-point scale defines the theoretical maximum as simply the number of actors present in the network multiplied by the maximum possible rating. The mean level of intra-team advice and hindrance density for each team (SO and MI) were found to be .743 and .714 and .487 and .474, respectively, with standard deviations of .108, .110, .165, and .156. The mean level of inter-team advice and hindrance density was found to be .590 and .462 with a standard deviation of .101 and .111, respectively.

Calculating communication density is slightly more complicated in that the theoretical maximum is set to that of the maximum possible amount of communication for each channel. In order to make the density score comparable across cases, each dyadic relationship was standardized by dividing it by the theoretical maximum of 1800 seconds. Once standardized, density can be defined as the proportion of the sum of the all dyadic relationships with the number of possible dyadic relationships in the network (Goldberg, 1984). Because few relationships approached this theoretical maximum, the apparent communication density scores are much lower than those observed with the advice and hindrance scores (SO team mean = .043, standard deviation = .037; MI team mean = .037, standard deviation = .046; inter-team mean = .040, standard deviation = .034).

Hypotheses four and five utilized quadratic assignment procedures (QAP) in order to measure the level of similarity between the relational structures of the three measured networks. QAP measures the level of convergence between network structures and is interpreted as a zero-order correlation with a range of negative one (perfect contra-alignment) to zero (misalignment) to positive one (perfect alignment; Mathieu, et al., 2000). Because QAP accounts for the dyadic structure of the network, rather than the overall structure, there is no need to separate the measured networks into within- and between-team subgroups during analysis, rather the aggregated set of dyadic relationships for each sub-group comparison of interest. With this, each MTS had six calculated QAP correlations measuring the correspondence between the communication and advice and communication and hindrance networks within each team and between the two teams. These correlations showed wide variation across teams and MTSs ranging between -.93 and 1.00 for the intra-team relationships and -.78 and .85 for the inter-team relationships.

Control Variables

Each analysis included a consistent set of control variables to account for the three manipulation and environmental/mission conditions to which each MTS was exposed. There were two versions of the mission environment within which the MTS performed that had the same overall characteristics, but differed in the exact location and distribution of threats, hotspots, and information. Each manipulation had two conditions and was intended to be fully crossed, though, due to the removal of invalid sessions, the exact distribution across all conditions is not perfectly balanced (varying between 3 and 6 for all possible permutations of the four conditions and 34 and 41 for each individual condition). Each of the manipulations intended to affect the focus of the members of the MTS either towards team- or MTS-level processes. The first manipulation varied the extent to which the focus laid on team- versus MTS-level processes in the training provided to each component team leader. The second manipulation varied the focus of the mission specific information provided to all of the members of the MTS before they started the performance episode. Lastly, the third manipulation varied the focus of feedback provided to all members of the MTS throughout the performance episode. Any differences in performance due to these four factors were captured with the inclusion of four separate dichotomous variables in the first step of each regression analysis and as level-1 predictors of the level-0 intercept for the HLM analyses (see Table 2). Because the effects of these manipulations are not related to the hypotheses within this thesis, the effects of said on collective states and processes were not analyzed, but rather the effects of said relationships of interest on performance are captured after accounting for the effects on performance by the manipulation and mission conditions themselves.

Table 2: HLM analyses of team performance on MTS membership and experimental manipulation condition

	Model 1			Model 2		
Random Effects	**Variance Component**	***df***	**χ^2 (N = 126)**	**Variance Component**	***df***	**χ^2 (N = 120)**
Teams (Level 1)	.516			.516		
MTSs (Level 2)	.488	62	179*	.390	58	146*
Parameter Estimates	**B**	**S.E.**	**T**	**B**	**S.E.**	**T**
Intercept	0.000	0.109	0.000	.280	.236	1.19
Control Vars.						
Manip 1				-.613	.195	-3.14*
Manip 2				.346	.207	1.67†
Manip 3				-.218	.192	-1.13
Mission				-.147	.204	-0.720

Note: Parameters significant at $p < .05$ are indicated with an asterisk (*) and parameters significant at $p < .10$ are indicated with a cross (†). Manip = Manipulation.

Analytic Approach. A total of nine density scores were calculated; three for each measured relationship in order to capture the different structures expected to exist within each team and between the component teams within the MTS. Intra-team densities were calculated by including only those relationships which existed between members that are were on the same component team and inter-team densities were calculated by including only those relationships which existed between members with opposing component team membership. Thus, each density score was calculated with a non-overlapping set of twelve directed dyadic relationships. Hypotheses 1a, 2a, and 3a sought to test relationships between collective phenomena and performance occurring at the team level. Because of the aforementioned concern regarding the non-independence of team observations within each independent MTS, HLM was used to assess these relationships. The variables of interest for each hypothesis (communication, advice, and hindrance densities, respectively) were included in level-0 while level-1 captures MTS membership and the set of MTS-level control variables. Hypotheses 1b, 2b, and 3b sought to test relationships at the MTS level and, thus, do not suffer from the same concerns regarding non-independence as each MTS was collected as an independent observation. Therefore, a multiple linear regression was conducted to test each hypothesis with the aforementioned MTS performance metric as the dependent variable with the collective phenomena of interest to each hypothesis (communication, advice, and hindrance densities, respectively) as independent variable. The same set of control variables as what was included in the HLM analyses were also included as controls in these multiple regression analyses.

To test hypotheses four and five, both the density and QAP correlation indices were utilized in the respective HLM (4a and 5a) and multiple regression (4b and 5b) analyses. As these hypotheses are all focused on the potential moderator effects of process-state alignment on communication density, centered cross-products for each relationship were calculated. For each analysis, performance (team or MTS) was once again the dependent variable and the aforementioned set of control variables was included as described for the previous analyses. To properly estimate the effect of the potential moderating variable, the main effects must be estimated first. Therefore, the communication and state (advice or hindrance) densities as well as the QAP correlation corresponding to each hypothesis were first included as predictors. The next step was to include the respective cross-product variable as a predictor and test for the presence of a significant level of additional variance explained. Only when this final estimate was found to explain significant incremental variance in predicting performance could the respective hypothesis have even partial support. Lastly, to gain full support if significant variance was explained by the interaction term, the pattern of the simple effects were observed and compared to that which was predicted by the corresponding hypothesis. Only when there is a significant interaction term and the observed pattern matched the predicted can each hypothesis be fully supported.

CHAPTER 3

RESULTS

Table 3 reports the zero-order correlations of all variables included in subsequent analyses. It was found that, overall, density scores between the advice, hindrance, and communication networks were largely uncorrelated with one another. Of the 36 within- and between-team process correlations, ten were found to be significant at the $p < .05$ level. There were only two consistent patterns of significance, one of which occurred between inter-team advice density, both intra-team advice densities, and inter- and intra-team hindrance densities. This pattern indicates that as advice relationships are perceived as being strong between teams, both advice and hindrance relationships within and between teams are also perceived as being stronger. The other consistent pattern of significance occurred between inter-team hindrance density and both intra-team hindrance densities indicating that as perception of hindrance relationships between teams is strong, similar perceptions of hindrance relationships exist within each component team. Overall, these results show generally weak relationships between the strength of communication, advice, and hindrance relationships existing both within and between teams in an MTS. However, these results are fully at the collective level and fail to capture the direct influence of the strength of each dyadic relationship on the strength of the others.

Table 3: All measured and derived variable descriptive statistics

	Mean	SD	Min	Max	MTS Com	SO Com	MI Com	MTS Adv	SO Adv	MI Adv	MTS Hin	SO Hin	MI Hin	MTS AC
MTS Com	.04	.03	.00	.19										
SO Com	.04	.04	.00	.15	-.22									
MI Com	.04	.05	.00	.25	.24*	-.17								
MTS Adv	.59	.10	.38	.89	-.06	-.02	-.19							
SO Adv	.68	.14	.33	1.00	-.05	.05	-.10	.48*						
MI Adv	.64	.14	.29	.96	.02	-.17	.09	.24*	.15					
MTS Hin	.46	.11	.26	.79	-.02	.24*	.08	.42*	.11	.00				
SO Hin	.36	.21	.00	1.00	.06	.23*	-.04	.28*	.12	-.07	.56*			
MI Hin	.34	.19	.00	.75	.02	.07	.17	.33*	.16	.03	.63*	.08		
MTS AC	.14	.34	-.56	.85	-.11	.08	.00	-.08	.25*	-.13	-.20	.11	-.13	
SO AC	.23	.46	-.88	.99	-.24*	.09	.08	-.15	.16	-.14	-.15	.09	-.05	.77*
MI AC	.30	.44	-.65	1.00	.03	.09	.14	.13	.05	-.10	.38*	.12	.50*	-.14
MTS HC	-.01	.36	-.78	.76	-.07	.16	-.01	.13	-.01	-.04	.10	.01	.18	.45*
SO HC	.16	.60	-.89	1.00	-.08	.07	.01	.09	.05	-.07	.28*	.06	.45*	-.02
MI HC	.02	.56	-.93	1.00	-.07	-.20	-.18	-.02	-.04	.10	-.13	-.20	-.15	-.15
MTS Perf	159	315	0	1590	.37*	-.24*	.15	-.24*	.05	-.13	-.14	-.12	.02	.15
SO Perf	15	10	0	39	.04	-.08	.02	.20	.19	.07	.05	.08	.03	.05
MI Perf	13	11	0	62	.01	-.12	-.02	-.10	-.07	.20	-.15	-.14	-.21	.06

Note: N = 75; Correlations significant at p < .05 are indicated by an asterisk (*). MTS = Inter-Team, SO = Intra-Team (SO Team), MI = Intra-Team (MI Team), Com = Communication Density, Adv = Advice Density, Hin = Hindrance Density, AC = Advice-Communication QAP Correlation, HC = Hindrance-Communication QAP Correlation, Perf = Performance.

Table 3 (Cont.): All measured and derived variable descriptive statistics

	SO AC	MI AC	MTS HC	SO HC	MI HC	MTS Perf	SO Perf
MTS Com							
SO Com							
MI Com							
MTS Adv							
SO Adv							
MI Adv							
MTS Hin							
SO Hin							
MI Hin							
MTS AC							
SO AC							
MI AC	-.08						
MTS HC	.28*	.27*					
SO HC	-.04	.51*	.28*				
MI HC	-.10	.02	.02	.16			
MTS Perf	.19	.10	-.02	.15	-.06		
SO Perf	.05	.01	.10	.03	.00	-.04	
MI Perf	.02	-.21	.05	-.08	.15	-.03	.41*

Note: N = 75; Correlations significant at p < .05 are indicated by an asterisk (*). MTS = Inter-Team, SO = Intra-Team (SO Team), MI = Intra-Team (MI Team), Com = Communication Density, Adv = Advice Density, Hin = Hindrance Density, AC = Advice-Communication QAP Correlation, HC = Hindrance-Communication QAP Correlation, Perf = Performance.

The correlation of these networks measured at the dyadic-relationship level within each MTS was assessed through QAP correlations which were aggregated across each of the collectives of interest (SO intra-team, MI intra-team, and inter-team relationships). This allowed for the use of a one sample t-test to detect the existence of significant relationships between these phenomena at the dyadic-level reported in Table 4. Several significant positive correlations were found to exist across MTSs indicating reasonably stable relationships between both intra- and inter-team states and process. The most consistent observed relationships were those between advice and communication relationships which were found to be significantly related to one another across all three sets of collective relationships (r = .142, .232, and .295 for inter-team, SO intra-team, and MI intra-team, respectively). This indicates a weak to moderate relationship between the amount of communication that occurred between any two individuals and their corresponding perception of informational value that the other holds. That is, as ones perception of another's informational value increases, the extent to which the first person will communicate with the second also increases. Additionally, supplemental paired-sample tests found that this relationship is significantly stronger within than between teams (.232 > .142: $t(73) = -2.59$, $p < .05$; .295 > .142: $t(72) = -2.09$, $p < .05$). The remaining significant findings of the one sample t-tests showed no consistent pattern. The hindrance and communication relationship was found to only be significant for the SO intra-team relationships (r = .162, p < .05). The association between advice and hindrance relationships was found to be moderately strong and significant for inter-team relationships (r = .292), much weaker for the MI intra-team relationships (r = .120), and negative but non-significant for the SO intra-team relationships (r = -.058). With this, there does not appear to be a stable advice-hindrance or hindrance-communication relationship across the three collectives of interest.

Table 4: T-Test of QAP correlations of density scores across advice, hindrance, and communication

	T-Score	Degrees of Freedom	Significance Level	Mean Difference	95% CI Upper, Lower
MTS Adv-Com	3.59	74	$p < .001$	.142	.063, .221
SO Adv-Com	4.38	73	$p < .001$	.232	.126, .337
MI Adv-Com	5.68	72	$p < .001$	.295	.192, .399
MTS Hin-Com	-0.27	73	*nsig.*	-.011	-.094, .072
SO Hin-Com	2.30	69	$p < .05$	.164	.022, .306
MI Hin-Com	0.33	67	*nsig.*	.023	-.114, .160
MTS Adv-Hin	7.47	74	$p < .001$	.292	.214, .370
SO Adv-Hin	-1.04	71	*nsig.*	-.058	-.168, .052
MI Adv-Hin	2.32	71	$p < .05$	.120	.017, .223

Note: The differences in degrees of freedom across the analyses are due to specific missing cases arising from a lack of variance across dyadic relationships resulting in an incalculable QAP correlation.
MTS = Inter-Team, SO = SO Team, MI = MI Team; Adv-Com = Advice-Communication QAP Correlation, Hin-Com = Hindrance-Communication QAP Correlation, Adv-Hin = Advice-Hindrance QAP Correlation.

Direct Relationships between Process, States, and Performance

Hypothesis 1 predicated that: (a) intra-team communication density would be positively related to team performance and (b) inter-team communication density would be positively related to MTS performance. Hypothesis 1 was partially supported. H1a was not supported; intra-team communication density was not predictive of team performance. H1b was supported; inter-team communication density positively predicted MTS. Results of the HLM analysis can be seen in Table 5 and show a non-significant level-0 coefficient (B = -.051, SE = .076, *n.s*) of intra-team communication on team performance after accounting for the level-1 effects of the MTS-level control variables. The results of the multiple regression analysis can be seen in Table 11 and show a significant effect of inter-team communication (β = .400, p < .05) explaining an additional 15.4% of the variance in MTS performance after accounting for the effects of the control variables.

Hypothesis 2 predicated that: (a) intra-team advice relationship density would be positively related to team performance and (b) inter-team advice relationship density would be positively related to MTS performance. Hypothesis 2 was partially supported. H2a was supported; team performance was significantly predicted by intra-team advice relationship density. H2b was not supported; MTS performance was not predicted by inter-team advice relationship density. The results of the HLM analysis can be seen in Table 5 and show a significant level-0 coefficient (B = .154, SE = .070, p < .05) of intra-team advice relationship density on team performance after accounting for the level-1 effects of the MTS-level control variables explaining approximately 10% of the variance on team performance beyond that explained by the control variables (Table 2). The results of the multiple regression analysis can be seen in Table 11 and show a non-significant (though it may be considered marginally significant) effect of inter-team advice relationship density (β = -.210, $p < .10$) explaining an additional 4.2% of the variance in MTS performance after accounting for the effects of the control variables.

Hypothesis 3 predicated that: (a) intra-team hindrance relationship density would be positively related to team performance and (b) inter-team hindrance relationship density would be positively related to MTS performance. Hypothesis 3 was not supported as neither team performance was not significantly predicted by intra-team hindrance relationship density nor was MTS performance predicted by inter-team hindrance relationship density. The results of the HLM analysis can be seen in Table 5 and show a non-significant level-0 coefficient (B = .069, SE = .067, *n.s*) of intra-team hindrance relationship density on team performance after accounting for the level-1 effects of the MTS-level control variables. The results of the multiple regression analysis can be seen in Table 11 and show a non-significant effect of inter-team hindrance relationship density (β = -.135, *n.s*) on MTS performance after accounting for the effects of the control variables.

To further test the direct relationships between advice, hindrance, and communication densities and performance, three supplementary analyses were conducted. The first two were designed to capture the impact of the three variables when included together on both team and MTS performance. The third was to observe the incremental validity of the significant MTS performance predictor, communication density, and the marginally significant predicator, advice relationship density. The first result can be found on Table 5 and the latter two on Table 11, respectively. The first analysis included advice, hindrance, and communication density as predictors of team performance. Similar to the analyses done on each of these predictors individually, only advice relationship density has a significant impact on team performance (B = .151, SE = .075, p < .05) The second analysis included advice, hindrance, and communication density as predictors of MTS performance finding an additional 18.9% of variance explained beyond the set of control variables. However, this was driven by the only significant individual predictor, communication (β = .388). The third analysis included only advice and communication density as predictors of MTS performance and explained an additional 18.6% of variance beyond the control variables which was, once again, driven by communication density (β = .387) while advice relationship density maintained marginal significance (β = -.181, p < .10).

The overall lack of support for this set of hypotheses prompted further supplemental analyses in an attempt to better understand what may be driving these relationships or the lack thereof. One possible cause identified is due to unintended effects of the between-subjects manipulation conditions not of interest in this thesis. To test this possibility analyses were conducted to capture the extent to which there are differences in the effects of these team and MTS processes on performance across the four manipulation conditions (i.e., one control and one experimental condition for each of two manipulations). Tables 6 through 10 show the results of these analyses at the team level while Tables 12 through 16 show the results at the MTS level.

At the team level, no significant effects (at p < .05) for any of the three process variables were found in any single condition of the manipulations. This was likely driven by the very low sample size within each analysis which ranged from 24 to 36 teams.

Despite this, potential differences in the effects were observed across the conditions. Communication was found to have a positive coefficient in two conditions (Tables 7 & 8) and a negative coefficient in the other two (Tables 6 & 9). Advice was found to have a positive coefficient in all conditions and approach significance ($p < .10$) in one condition (Table 9). Lastly, hindrance was found to have a positive coefficient in two conditions (Tables 8 & 9), approaching significance ($p < .15$) in one condition (Table 8), and having a negative coefficient in the other two conditions (Tables 6 & 7).

Given the concerns of low sample size and the potential differential effects of the remaining control variables across the manipulation conditions, an additional supplemental analysis was conducted. Each of the four manipulation conditions were dummy coded and an interaction term for each condition with each of the three processes were calculated. This allows for a test of the presence of significant differences in the relationships of the processes with performance across the manipulation conditions. The comparison condition for each process was determined by using the condition with the greatest absolute value coefficient as observed in the previous set of analyses (Tables 6 through 9). Table 10 shows the results of these analyses. There were no significant differences in the effects of either communication or advice on team performance across the manipulation conditions. However, there was a marginally significant ($p < .10$) difference between the effect of hindrance between two conditions (Tables 7 & 8).

At the MTS level, significant effects (at $p < .05$) were only found for communication in one condition (Table 15) and marginally significant effects ($p < .10$) were found for communication in one additional condition (Table 12) and advice in one condition (Table 15). All coefficients were observed to maintain a consistent direction (positive for communication, negative for advice and hindrance) across all conditions except for a weak positive coefficient for advice in one condition (Table 12). Given the continued concern of low sample size and the potential differential effects of the remaining control variables across the manipulation conditions, a supplemental analysis homologous to that described at the team level was conducted. Table 16 shows the results of these analyses. There were no significant differences in the effects of any of the process variables on MTS performance across the manipulation conditions.

Moderated Relationships between Process, States, and Performance

Hypothesis 4 predicted that the effects of: (a) intra-team communication density on team performance and (b) inter-team communication density on MTS performance is moderated by the degree of alignment between the corresponding communication and advice relationship networks. No significant effect of the interaction term on team performance (B = .028, SE = .067, *n.s*) was found in the HLM analyses which can be seen on Table 17 – Model 1 failing to support H4a. A significant effect of the interaction term on MTS performance (β = .330) was found to explain an additional 5.8% of variance between the control variables, inter-team communication density, inter-team advice relationship density, and the alignment of inter-team communication and advice relationships which can be seen on Table 23 – Model 1.

H4b stated that the relationship between inter-team communication amount and MTS performance is stronger when the moderator is positive and weaker when the moderator is negative. Figure 8 shows the observed interactive effect of amount of communication and the degree of communication-advice relationship alignment. These results appear to support hypothesis 4b indicating an overall positive relationship between the amount of inter-team communication and MTS performance and a stronger relationship (i.e., larger absolute difference between amounts of communication) when the structure is aligned and a weaker relationship (i.e., smaller absolute difference between amounts of communication) when the structure is contra-aligned. Two supplemental analyses were conducted to test the strength of the effect of amount of inter-team communication on MTS performance when structure is contra-aligned versus aligned which can be seen in Table 23.

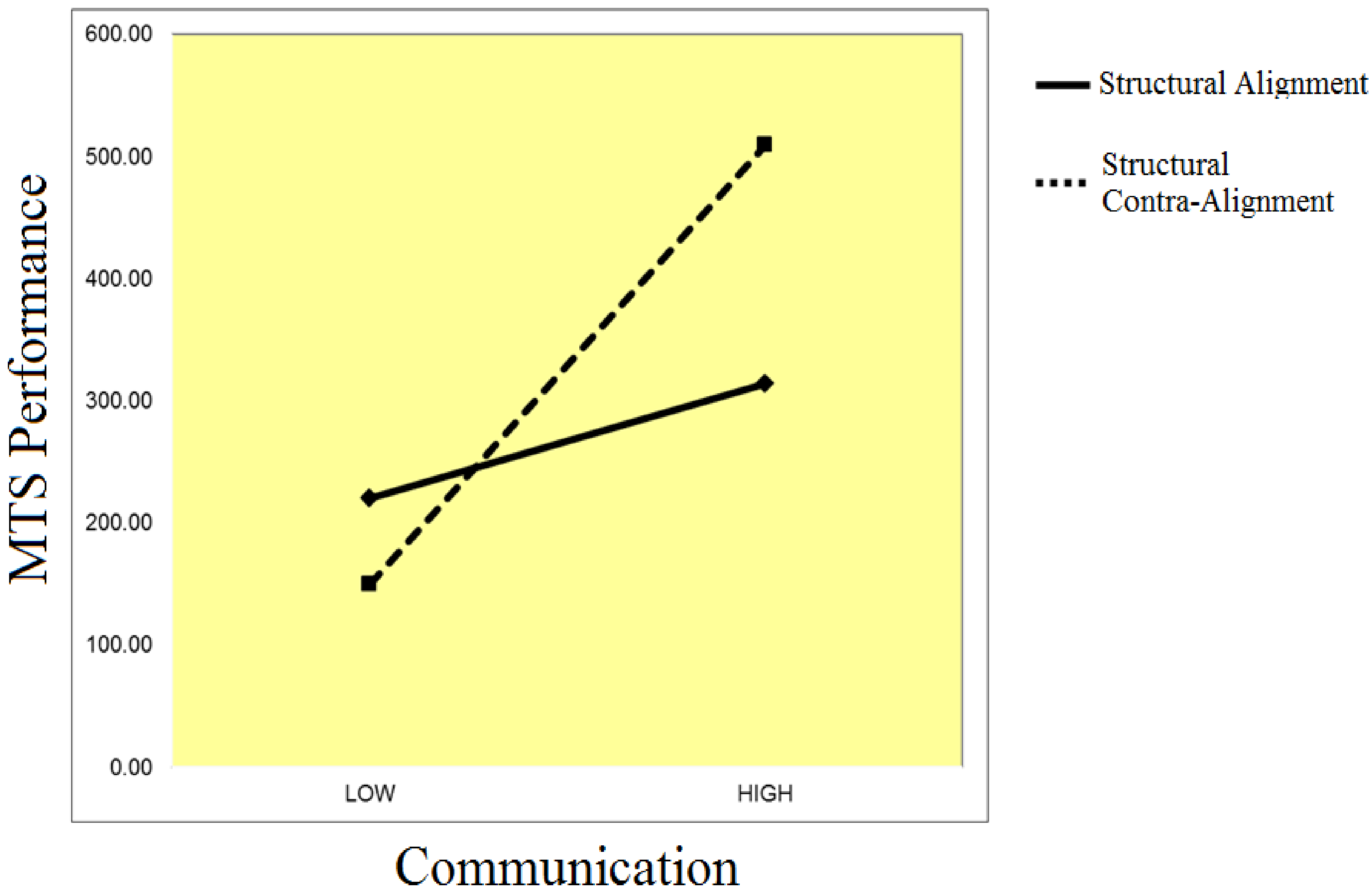

Figure 8: Observed interaction effect between communication amount and advice-communication structural alignment in predicting MTS performance (Hypothesis 4b).

Models 3 and 4 indicate the strength of the relationship between communication and performance when there is alignment and contra-alignment between advice and communication, respectively. When the advice-communication structure was observed to be contra-aligned, amount of communication (β = .390, p < .05) explained an additional 14.2% of variance in MTS performance beyond the control variables and the density of the advice relationship while advice-communication structural alignment resulted in a stronger incremental effect of amount of communication (β = .471, p < .05) which explained an additional 21.8% of variance in MTS performance. Taken together, these results suggest clear and strong support for Hypothesis 4b.

Hypothesis 5 predicted that the effects of: (a) intra-team communication density on team performance and (b) inter-team communication density on MTS performance is moderated by the degree of alignment between the corresponding communication and hindrance relationship networks. No significant effect of the interaction term on MTS performance (β = .011, *n.s*) was found in the multiple regression analysis which can be seen in Table 23 – Model 2 indicating a lack of support for H5b. Homologous to the supplemental analyses conducted for the moderating effect of advice-communication alignment, Table 23 (Models 5 and 6) present an analysis focusing on the alignment of hindrance and communication.

Unexpectedly, the variance explained by communication varied substantially between the alignment and contra-alignment subgroups. When the hindrance-communication structure was observed to be aligned, amount of communication (β = .240, *n.s*) explained an additional 5.3% of the variance in MTS performance. Conversely, when contra-alignment was observed, communication amount (β = .408, p < .05) explained

14.6% of variance. While this suggests a significant moderation effect that wasn't observed using the cross-product communication by hindrance-communication alignment in the multiple regression moderation analysis (Table 23 – Model 2), there is a major concern due to the differential impacts of the control variables. The control variables explained 24.4% of the variance in MTS performance when alignment was observed and only 17.0% of the variance when contra-alignment was observed. This pattern of results suggests the possibility of additional moderation due to the manipulation conditions which will be discussed later.

At the team level, a significant effect of the interaction term on team performance ($B = .157$, $SE = .066$, $p < .05$) was found in the HLM analysis which can be seen on Table 17 – Model 2. By comparing the variance components between a model including all variables other than the interaction term of interest (Table 17 – Model 3) with the model indicated in Table 17 – Model 2, a pseudo r-squared (variance explained) was calculated. It was found that the interaction term explained approximately 4.6% of variance in team performance after accounting for the MTS-level experimental control variables, intra-team communication and hindrance relationship density, and communication-hindrance structural alignment. Hypothesis 5a stated that the relationship between intra-team communication amount and team performance is positive when the moderator is negative and negative when the moderator is positive. Figure 9 shows the observed interactive effect of amount of intra-team communication and the degree of communication-hindrance structural alignment. These results are in direct contrast with H5a indicating a positive relationship between intra-team communication and performance when the communication-hindrance structure is aligned and a negative relationship when the said structure is contra-aligned. Thus, though the interaction term was significant and the strength of the moderator changed the direction of the relationship, it did so opposite to what was hypothesized and thus H5a was not supported. Possible reasons as to why this unexpected relationship was observed will be discussed.

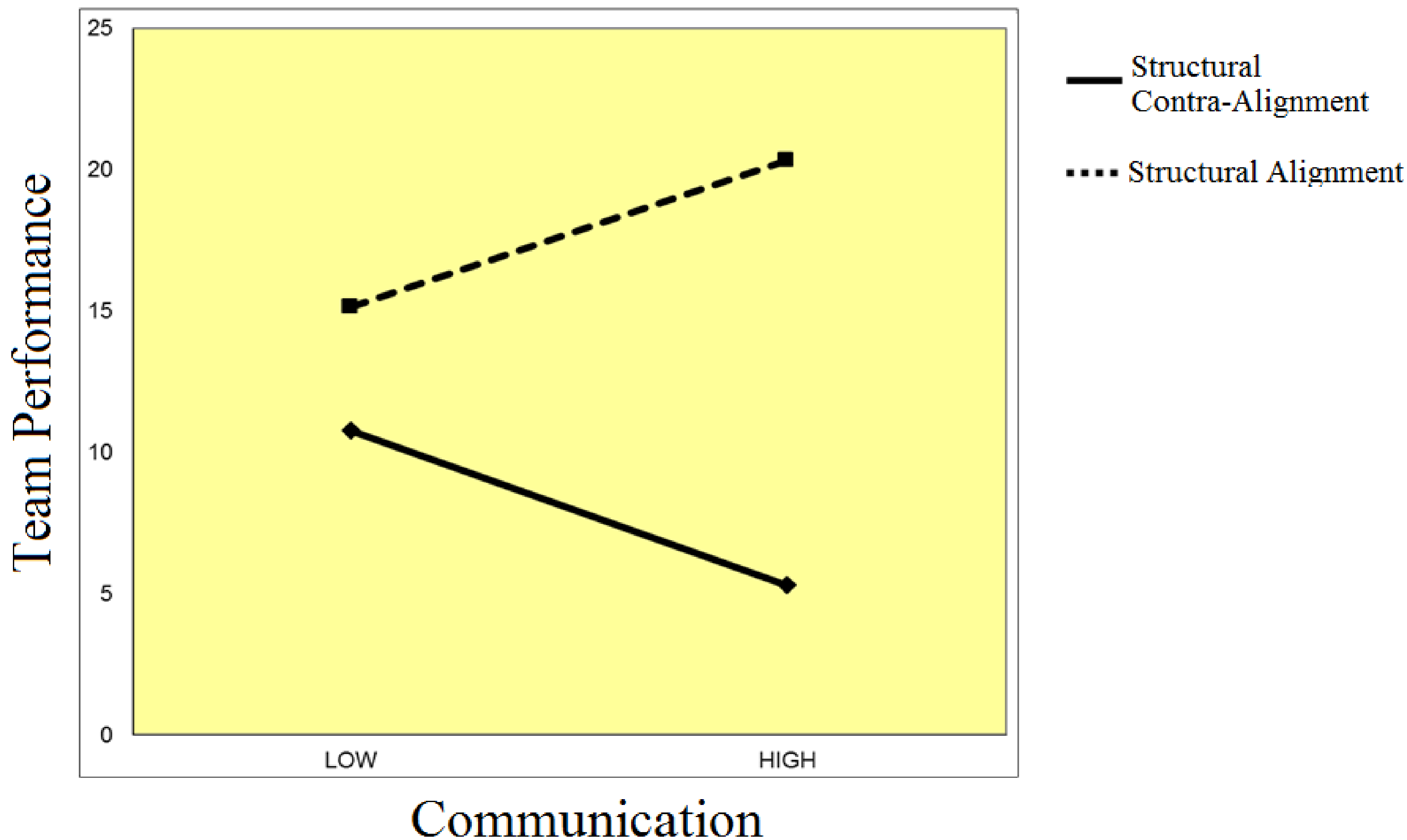

Figure 9: Observed interaction effects between communication amount and hindrance-communication structural alignment in predicting team performance (Hypothesis 5a).

Similar to the concerns raised on the pattern of observed direct effects of the processes of interest, there may exist differential relationships due to the effects of the manipulation conditions. At the team level, Tables 18 through 22 display the results of analyses intended to parse out potential differences in the moderating effects of advice-communication and hindrance-communication alignment on the relationship between communication and team performance. The moderating effect of hindrance-communication alignment was relatively stable across all manipulation conditions though it was only statistically significant ($p < .05$) in one (Table 18). No significant difference was observed between the strength of the moderation effect across any of the manipulation conditions (Table 22).

Conversely, the moderating effect of advice-communication alignment was highly varied across the manipulation conditions and was found to be significantly positive in one condition (Table 21), significantly negative in one condition (Table 20), and non-significantly positive and negative in the two remaining conditions (Tables 18 & 19, respectively). Significant differences were found to exist between the two positive (Tables 18 & 21) and the two negative (Tables 19 & 20) moderation effects indicating that advice-communication alignment differentially weakened the effect on team performance in some conditions (Tables 19 & 20) and strengthened the effect in others (Tables 18 & 21).

A homologous set of analyses were conducted at the MTS level as well to detect similar differential moderating effects of alignment on the effect of communication on MTS performance. Table 24 shows that the effect of advice-communication alignment on the effect of communication on performance was relatively stable. While all coefficients were positive, only one was marginally significant ($p < .10$; Model 5). The observed differences were found to be non-significant in the subsequent analysis shown in Table 25 – Model 1. Conversely, the effect of hindrance-communication alignment moderating the relationship between communication and performance was found to be highly variable across manipulation conditions. Table 21 – Model 2 indicates a significant ($p < .05$) negative moderating relationship while Model 8 indicates a non-significant negative relationship. Models 4 and 6, however, indicate non-significant positive moderating relationships. The significance of these observed differences are displayed in Table 25 – Model 2. The two positive coefficients in Models 4 and 6 were found to be significantly different than the coefficient in Model 2 at a significance level of 0.10 and 0.05, respectively. This indicates that hindrance-communication alignment weakened the effect of communication on performance in some conditions (Table 24 – Models 2 and 8) and strengthened the effect in others (Table 24 – Models 4 and 6). The interpretation of this pattern of results will be discussed later.

Table 5: HLM analyses of team performance on intra-team process

	Model 1			Model 2			Model 3			Model 4		
Random Effects	**Variance Component**	***df***	**χ^2 (N = 126)**	**Variance Component**	***df***	**χ^2 (N = 126)**	**Variance Component**	***df***	**χ^2 (N = 126)**	**Variance Component**	***df***	**χ^2 (N = 126)**
Teams (Level 1)	.522			.523			.518			.531		
MTSs (Level 2)	.384	58	143*	.350	58	135*	.388	58	144*	.339	58	130*
Parameter Estimates	**B**	**S.E.**	**T**	**B**	**S.E.**	**T**	**B**	**S.E.**	**T**	**B**	**S.E.**	**T**
Intercept	.272	.233	1.17	.212	.222	0.954	.286	.233	1.23	.199	.216	0.923
Control Vars.												
Manip 1	-.610	.195	-3.13*	-.595	.188	-3.16*	-.611	.195	-3.13*	-.588	.188	-3.13*
Manip 2	.357	.206	1.73†	.372	.202	1.84†	.353	.207	1.71†	.400	.202	1.98†
Manip 3	-.225	.193	-1.17	-.210	.185	-1.14	-.219	.193	-1.14	-.223	.185	-1.21
Mission	-.138	.203	-0.680	-.067	.201	-0.335	-.165	.203	-0.814	-.067	.199	-0.338
Communication	-.051	.076	-0.675							-.089	.081	-1.10
Advice				.154	.070	2.20*				.151	.075	2.16*
Hindrance							.069	.067	1.02	.073	.074	0.994

Note: Parameters significant at $p < .05$ are indicated with an asterisk (*) and parameters significant at $p < .10$ are indicated with a cross (†).

Table 6: HLM analyses of team performance on intra-team process when Manipulation 1 & 2 = Control

	Model 1			**Model 2**			**Model 3**		
Random Effects	**Variance Component**	***df***	**χ^2 (N = 32)**	**Variance Component**	***df***	**χ^2 (N = 32)**	**Variance Component**	***df***	**χ^2 (N = 32)**
Teams (Level 1)	.276			.314			.307		
MTSs (Level 2)	.403	13	50.5*	.395	13	45.1*	.421	13	47.5*
Parameter Estimates	**B**	**S.E.**	**T**	**B**	**S.E.**	**T**	**B**	**S.E.**	**T**
Intercept	.252	.401	0.621	.253	.401	0.623	.268	.437	0.613
Control Vars.									
Manip 3	-.782	.282	-2.78*	-.719	.279	-2.58	-.760	.289	-2.63*
Mission	.101	.339	0.297	.055	.375	0.146	.072	.364	0.199
Communication	-.145	.093	-1.565						
Advice				.054	.155	0.347			
Hindrance							-.021	.099	-0.216

Note: Parameters significant at $p < .05$ are indicated with an asterisk (*) and parameters significant at $p < .10$ are indicated with a cross (†).

Table 7: HLM analyses of team performance on intra-team process when Manipulation 1 = Experimental & Manipulation 2 = Control

	Model 1			**Model 2**			**Model 3**		
Random Effects	**Variance Component**	***df***	**χ^2 (N = 24)**	**Variance Component**	***df***	**χ^2 (N = 24)**	**Variance Component**	***df***	**χ^2 (N = 24)**
Teams (Level 1)	.288			.278			.294		
MTSs (Level 2)	.356	9	30.8	.386	9	33.6	.355	9	30.2
Parameter Estimates	**B**	**S.E.**	**T**	**B**	**S.E.**	**T**	**B**	**S.E.**	**T**
Intercept	-.289	.331	-0.873	-.318	.329	-0.966	-.311	.327	-0.953
Control Vars.									
Manip 3	.145	.341	0.426	.131	.343	0.380	.148	.324	0.457
Mission	-.100	.336	-0.297	-.083	.339	-0.245	-.095	.330	-0.288
Communication	.110	.167	0.658						
Advice				.083	.130	0.638			
Hindrance							-.048	.069	-0.690

Note: Parameters significant at $p < .05$ are indicated with an asterisk (*) and parameters significant at $p < .10$ are indicated with a cross (†).

Table 8: HLM analyses of team performance on intra-team process when Manipulation 1 = Control & Manipulation 2 = Experimental

	Model 1			Model 2			Model 3		
Random Effects	**Variance Component**	***df***	**χ^2 (N = 34)**	**Variance Component**	***df***	**χ^2 (N = 34)**	**Variance Component**	***df***	**χ^2 (N = 34)**
Teams (Level 1)	.867			.955			.853		
MTSs (Level 2)	.751	14	37.6	.577	14	30.2	.703	14	36.2
Parameter Estimates	**B**	**S.E.**	**T**	**B**	**S.E.**	**T**	**B**	**S.E.**	**T**
Intercept	.744	.312	2.39*	.659	.284	2.32*	.790	.299	2.64*
Control Vars.									
Manip 3	-.308	.468	-0.658	-.327	.416	-0.784	-.343	.455	-0.752
Mission	.003	.530	-0.005	.196	.609	0.321	-.048	.501	-0.096
Communication	.189	.278	0.680						
Advice				.180	.161	1.12			
Hindrance							.310	.198	1.56

Note: Parameters significant at $p < .05$ are indicated with an asterisk (*) and parameters significant at $p < .10$ are indicated with a cross (†).

Table 9: HLM analyses of team performance on intra-team process when Manipulation 1 & 2 = Experimental

	Model 1			Model 2			Model 3		
Random Effects	**Variance Component**	***df***	**χ^2 (N = 36)**	**Variance Component**	***df***	**χ^2 (N = 36)**	**Variance Component**	***df***	**χ^2 (N = 36)**
Teams (Level 1)	.582			.515			.554		
MTSs (Level 2)	.045	15	16.9	.130	15	21.8	.102	15	20.1
Parameter Estimates	**B**	**S.E.**	**T**	**B**	**S.E.**	**T**	**B**	**S.E.**	**T**
Intercept	-.345	.274	-1.26	-.313	.310	-1.01	-.311	.308	-1.01
Control Vars.									
Manip 3	.242	.264	0.915	.136	.324	0.421	.247	.284	0.869
Mission	-.152	.268	-0.566	-.095	.267	-0.355	-.254	.282	-0.901
Communication	-.142	.100	-1.42						
Advice				.183	.098	1.86†			
Hindrance							.082	.113	0.727

Note: Parameters significant at $p < .05$ are indicated with an asterisk (*) and parameters significant at $p < .10$ are indicated with a cross (†).

Table 10: HLM analyses of team performance on intra-team process comparing for differential effects across manipulation conditions

	Model 1			Model 2			Model 3		
Random Effects	**Variance Component**	***df***	**χ^2 (N = 126)**	**Variance Component**	***df***	**χ^2 (N = 126)**	**Variance Component**	***df***	**χ^2 (N = 126)**
Teams (Level 1)	.524			.532			.526		
MTSs (Level 2)	.384	58	141*	.358	58	133*	.383	58	140*
Parameter Estimates	**B**	**S.E.**	**T**	**B**	**S.E.**	**T**	**B**	**S.E.**	**T**
Intercept	.258	.229	1.13	.214	.224	0.955	.290	.233	1.24
Control Vars.									
Manip 1	-.593	.197	-3.01*	-.583	.188	-3.11*	-.616	.194	-3.18*
Manip 2	.354	.210	1.69†	.380	.202	1.88†	.352	.203	1.73†
Manip 3	-.205	.194	-1.06	-.241	.196	-1.23	-.202	.192	-1.06
Mission	-.129	.205	-0.629	-.047	.219	-0.216	-.173	.201	-0.859
Com Density	.189	.273	0.693						
Advice Density				.268	.117	2.30*			
Hin Density							.310	.209	1.49
00-Com	-.323	.287	-1.13						
10-Com	-.105	.318	-0.331						
11-Com	-.298	.292	-1.02						
00-Adv				-.158	.218	-0.724			
10-Adv				-.180	.175	-1.03			
01-Adv				-.128	.160	-0.800			
00-Hin							-.301	.232	-1.30
10-Hin							-.363	.219	-1.66†
11-Hin							-.233	.249	-0.938

Note: Parameters significant at $p < .05$ are indicated with an asterisk (*) and parameters significant at $p < .10$ are indicated with a cross (†). Manip = Manipulation, Com = Communication, Hin = Hindrance, AdvBYCom = Advice-Communication QAP Correlation, HinBYCom = Hindrance-Communication QAP Correlation, ComXAC = Cross-product of Communication Density and Advice-Communication QAP Correlation, ComXHC = Cross-Product of Communication Density and Hindrance-Communication QAP Correlation.

Table 11: Multiple regression analyses of MTS performance on inter-team process

	Model 1 (N = 75)	Model 2 (N = 75)	Model 3 (N = 75)	Model 4 (N = 75)	Model 5 (N = 75)
Step 1					
Manipulation 1	.185	.185	.185	.185	.185
Manipulation 2	-.128	-.128	-.128	-.128	-.128
Manipulation 3	.068	.068	.068	.068	.068
Mission	-.079	-.079	-.079	-.079	-.079
R^2	.059	.059	.059	.059	.059
F	1.10	1.10	1.10	1.10	1.10
Step 2					
Communication Density	.400*			.388*	.387*
Advice Density		-.210†		-.155	-.181†
Hindrance Density			-.135	-.062	
ΔR^2	.154	.042	.017	.189	.186
ΔF	13.5*	.205†	-.135	5.61*	8.36*

Note: Parameters significant at $p < .05$ are indicated with an asterisk (*) and parameters significant at $p < .10$ are indicated with a cross (†).

Table 12: Multiple regression analyses of MTS performance on inter-team process when Manipulation 1 & 2 = Control

	Model 1 (N = 19)	Model 2 (N = 19)	Model 3 (N = 19)	Model 4 (N = 19)	Model 5 (N = 19)
Step 1					
Manipulation 3	.225	.225	.225	.225	.225
Mission	-.409†	-.409†	-.409†	-.409†	-.409†
R^2	.210	.210	.210	.210	.210
F	2.122	2.122	2.122	2.122	2.122
Step 2					
Communication Density	.427†			.453†	.465†
Advice Density		.042		-.005	-.125
Hindrance Density			-.131	-.196	
ΔR^2	.182	.001	.017	.219	.194
ΔF	4.490†	.027	0.329	1.656	2.271

Note: Parameters significant at $p < .05$ are indicated with an asterisk (*) and parameters significant at $p < .10$ are indicated with a cross (†).

Table 13: Multiple regression analyses of MTS performance on inter-team process when Manipulation 1 = Control & Manipulation 2 = Experimental

	Model 1 (N = 21)	Model 2 (N = 21)	Model 3 (N = 21)	Model 4 (N = 21)	Model 5 (N = 21)
Step 1					
Manipulation 3	.215	.215	.215	.215	.215
Mission	-.312	-.312	-.312	-.312	-.312
R^2	.143	.143	.143	.143	.143
F	1.589	1.589	1.589	1.589	1.589
Step 2					
Communication Density	.294			.188	.229
Advice Density		-.268		-.209	-.196
Hindrance Density			-.222	-.184	
ΔR^2	.081	.071	.047	.146	.115
ΔF	1.882	1.621	1.037	2.206	1.319

Note: Parameters significant at $p < .05$ are indicated with an asterisk (*) and parameters significant at $p < .10$ are indicated with a cross (†).

Table 14: Multiple regression analyses of MTS performance on inter-team process when Manipulation 1 = Experimental & Manipulation 2 = Control

	Model 1 (N = 15)	Model 2 (N = 15)	Model 3 (N = 15)	Model 4 (N = 15)	Model 5 (N = 15)
Step 1					
Manipulation 3	-.072	-.072	-.072	-.072	-.072
Mission	.315	.315	.315	.315	.315
R^2	.095	.095	.095	.095	.095
F	0.632	0.632	0.632	0.632	0.632
Step 2					
Communication Density	.427			.441	.425
Advice Density		-.326		-.278	-.323
Hindrance Density			-.139	-.096	
ΔR^2	.156	.084	.019	.245	.238
ΔF	2.290	1.123	0.234	1.117	1.788

Note: Parameters significant at $p < .05$ are indicated with an asterisk (*) and parameters significant at $p < .10$ are indicated with a cross (†).

Table 15: Multiple regression analyses of MTS performance on inter-team process when Manipulation 1 & 2 = Experimental

	Model 1 (N = 19)	Model 2 (N = 19)	Model 3 (N = 19)	Model 4 (N = 19)	Model 5 (N = 19)
Step 1					
Manipulation 3	-.110	-.110	-.110	-.110	-.110
Mission	.079	.079	.079	.079	.079
R^2	.019	.019	.019	.019	.019
F	0.158	0.158	0.158	0.158	0.158
Step 2					
Communication Density	.564*			.614*	.566*
Advice Density		-.341		-.617†	-.344
Hindrance Density			-.148	.365	
ΔR^2	.277	.109	.022	.445	.387
ΔF	5.893*	1.876	0.337	3.607*	4.571*

Note: Parameters significant at $p < .05$ are indicated with an asterisk (*) and parameters significant at $p < .10$ are indicated with a cross (†).

Table 16: Multiple regression analyses of MTS performance on inter-team process comparing for differential effects across manipulation conditions

	Model 1 (N = 75)	Model 2 (N = 75)	Model 3 (N = 75)
Step 1			
Manipulation 1	.185		.185
Manipulation 2	-.128		-.128
Manipulation 3	.068		.068
Mission	-.079	-.075	-.079
R^2	.059	.009	.059
F	1.096	0.340	1.096
Step 2			
Communication Density	.400*		
Advice Density		-.210†	
Hindrance Density			-.135
ΔR^2	.154	.042	.017
ΔF	13.534*	3.259†	1.301
Step 3			
00xComm. Density	-.041		
10xComm. Density	.134		
01xComm. Density	-.334		
00xAdvice Density		.412	
10xAdvice Density		.102	
01xAdvice Density		.354	
00xHindrance Density			-.175
10xHindrance Density			-.052
01xHindrance Density			-.109
ΔR^2	.052	.004	.001
ΔF	1.555	0.111	0.033

Note: Parameters significant at $p < .05$ are indicated with an asterisk (*) and parameters significant at $p < .10$ are indicated with a cross (†). 00x = Manipulation 1 & Manipulation 2 control condition, 10x = Manipulation 1 experimental & Manipulation 2 control condition, 01x = Manipulation 1 control & Manipulation 2 experimental.

Table 17: HLM analyses of team performance on intra-team process and structural alignment moderation

	Model 1			Model 2			Model 3		
Random Effects	**Variance Component**	***df***	**χ^2 (N = 126)**	**Variance Component**	***df***	**χ^2 (N = 126)**	**Variance Component**	***df***	**χ^2 (N = 126)**
Teams (Level 1)	.541			.480			.406		
MTSs (Level 2)	.339	58	128*	.424	58	158*	.503	58	150*
Parameter Estimates	**B**	**S.E.**	**T**	**B**	**S.E.**	**T**	**B**	**S.E.**	**T**
Intercept	.187	.220	0.850	.279	.226	1.23	.259	.223	1.16
Control Vars.									
Manip 1	-.581	.188	-3.09*	-.633	.200	-3.17*	-.597	.196	-3.05*
Manip 2	.393	.203	1.94*	.381	.206	1.85†	.383	.206	1.86†
Manip 3	-.221	.190	-1.16	-.264	.198	-1.34	-.206	.194	-1.06
Mission	-.045	.202	-0.221	-.121	.208	-0.58	-.170	.203	-0.838
Com Density	-.066	.079	-0.837	-.010	.081	-0.12	-.070	.077	-0.911
Advice Density	.166	.074	2.25*						
AdvBYCom	-.021	.082	-0.258						
ComXAC	.028	.067	0.414						
Hin Density				.092	.076	1.20	.096	.075	1.29
HinBYCom				.113	.083	1.35	.117	.084	1.34
ComXHC				.157	.066	2.40*			

Note: Parameters significant at $p < .05$ are indicated with an asterisk (*) and parameters significant at $p < .10$ are indicated with a cross (†). Manip = Manipulation, Com = Communication, Hin = Hindrance, AdvBYCom = Advice-Communication QAP Correlation, HinBYCom = Hindrance-Communication QAP Correlation, ComXAC = Cross-product of Communication Density and Advice-Communication QAP Correlation, ComXHC = Cross-Product of Communication Density and Hindrance-Communication QAP Correlation.

Table 18: HLM analyses of team performance on intra-team process and structural alignment moderation when Manipulation 1 & 2 = Control

	Model 1			**Model 2**		
Random Effects	**Variance Component**	***df***	**χ^2 (N = 32)**	**Variance Component**	***df***	**χ^2 (N = 32)**
Teams (Level 1)	.308			.264		
MTSs (Level 2)	.421	13	46.1	.410	13	50.3
Parameter Estimates	**B**	**S.E.**	**T**	**B**	**S.E.**	**T**
Intercept	.278	.401	0.694	.310	.385	0.806
Control Vars.						
Manip 3	-.765	.267	-2.87*	-.867	.229	-3.789*
Mission	.032	.345	0.092	.133	.420	0.316
Com Density	-.154	.079	-1.95†	-.009	.099	-0.089
Advice Density	.012	.137	0.088			
AdvBYCom	-.090	.100	-0.904			
ComXAC	.039	.135	0.291			
Hin Density				-.018	.118	-0.151
HinBYCom				.070	.113	0.626
ComXHC				.181	.083	2.197*

Note: Parameters significant at $p < .05$ are indicated with an asterisk (*) and parameters significant at $p < .10$ are indicated with a cross (†). Manip = Manipulation, Com = Communication, Hin = Hindrance, AdvBYCom = Advice-Communication QAP Correlation, HinBYCom = Hindrance-Communication QAP Correlation, ComXAC = Cross-product of Communication Density and Advice-Communication QAP Correlation, ComXHC = Cross-Product of Communication Density and Hindrance-Communication QAP Correlation.

Table 19: HLM analyses of team performance on intra-team process and structural alignment moderation when Manipulation 1 = Experimental & Manipulation 2 = Control

	Model 1			Model 2		
Random Effects	**Variance Component**	***df***	**χ^2 (N = 24)**	**Variance Component**	***df***	**χ^2 (N = 24)**
Teams (Level 1)	.382			.300		
MTSs (Level 2)	.298	9	20.8	.451	9	32.5
Parameter Estimates	**B**	**S.E.**	**T**	**B**	**S.E.**	**T**
Intercept	-.295	.307	-0.960	-.367	.333	-1.100
Control Vars.						
Manip 3	.132	.339	0.389	.055	.315	0.175
Mission	-.101	.318	-0.316	.008	.372	0.020
Com Density	.067	.194	0.346	.042	.175	0.242
Advice Density	.073	.108	0.675			
AdvBYCom	.051	.146	0.347			
ComXAC	-.158	.265	-0.596			
Hin Density				-.021	.093	-0.223
HinBYCom				.128	.155	0.830
ComXHC				.128	.157	0.819

Note: Parameters significant at $p < .05$ are indicated with an asterisk (*) and parameters significant at $p < .10$ are indicated with a cross (†). Manip = Manipulation, Com = Communication, Hin = Hindrance, AdvBYCom = Advice-Communication QAP Correlation, HinBYCom = Hindrance-Communication QAP Correlation, ComXAC = Cross-product of Communication Density and Advice-Communication QAP Correlation, ComXHC = Cross-Product of Communication Density and Hindrance-Communication QAP Correlation.

Table 20: HLM analyses of team performance on intra-team process and structural alignment moderation when Manipulation 1 = Control & Manipulation 2 = Experimental

	Model 1			Model 2		
Random Effects	**Variance Component**	***df***	**χ^2 (N = 34)**	**Variance Component**	***df***	**χ^2 (N = 34)**
Teams (Level 1)	.807			.927		
MTSs (Level 2)	.626	14	33.2	.749	14	33.3
Parameter Estimates	**B**	**S.E.**	**T**	**B**	**S.E.**	**T**
Intercept	.453	.347	1.305	.786	.329	2.39*
Control Vars.						
Manip 3	-.311	.479	-0.649	-.361	.484	-0.746
Mission	.622	.616	1.01	-.018	.507	-0.035
Com Density	.195	.218	0.893	.123	.256	0.483
Advice Density	.275	.196	1.40			
AdvBYCom	-.094	.242	-0.389			
ComXAC	-.690	.152	-4.55*			
Hin Density				.310	.213	1.45
HinBYCom				.091	.197	0.463
ComXHC				.149	.200	0.745

Note: Parameters significant at $p < .05$ are indicated with an asterisk (*) and parameters significant at $p < .10$ are indicated with a cross (†). Manip = Manipulation, Com = Communication, Hin = Hindrance, AdvBYCom = Advice-Communication QAP Correlation, HinBYCom = Hindrance-Communication QAP Correlation, ComXAC = Cross-product of Communication Density and Advice-Communication QAP Correlation, ComXHC = Cross-Product of Communication Density and Hindrance-Communication QAP Correlation.

Table 21: HLM analyses of team performance on intra-team process and structural alignment moderation when Manipulation 1 & 2 = Experimental

	Model 1			Model 2		
Random Effects	**Variance Component**	***df***	**χ^2 (N = 36)**	**Variance Component**	***df***	**χ^2 (N = 36)**
Teams (Level 1)	.521			.616		
MTSs (Level 2)	.057	15	16.4	.001	15	11.8
Parameter Estimates	**B**	**S.E.**	**T**	**B**	**S.E.**	**T**
Intercept	-.295	.271	-1.09	-.396	.232	-1.71
Control Vars.						
Manip 3	-.052	.301	-0.174	.243	.223	1.09
Mission	.138	.230	0.600	-.112	.219	-0.510
Com Density	-.095	.120	-0.792	-.174	.137	-1.27
Advice Density	.254	.091	2.79*			
AdvBYCom	.065	.141	0.461			
ComXAC	.186	.068	2.74*			
Hin Density				.123	.172	0.728
HinBYCom				-.198	.148	-1.34
ComXHC				.102	.167	0.613

Note: Parameters significant at $p < .05$ are indicated with an asterisk (*) and parameters significant at $p < .10$ are indicated with a cross (†). Manip = Manipulation, Com = Communication, Hin = Hindrance, AdvBYCom = Advice-Communication QAP Correlation, HinBYCom = Hindrance-Communication QAP Correlation, ComXAC = Cross-product of Communication Density and Advice-Communication QAP Correlation, ComXHC = Cross-Product of Communication Density and Hindrance-Communication QAP Correlation.

Table 22: HLM analyses of team performance on intra-team process and structural alignment moderation comparing for differential effects across manipulation conditions

	Model 1			Model 2		
Random Effects	**Variance Component**	***df***	**χ^2 (N = 126)**	**Variance Component**	***df***	**χ^2 (N = 126)**
Teams (Level 1)	.494			.487		
MTSs (Level 2)	.335	58	132*	.433	58	156*
Parameter Estimates	**B**	**S.E.**	**T**	**B**	**S.E.**	**T**
Intercept	.151	.220	0.687	.271	.224	1.21
Control Vars.						
Manip 1	-.568	.183	-3.11*	-.630	.198	-3.18*
Manip 2	.410	.197	2.08*	.376	.207	1.81†
Manip 3	-.300	.189	-1.58	-.260	.199	-1.31
Mission	.083	.200	0.415	-.112	.209	-0.535
Com Density	-.028	.080	-0.344	-.005	.080	-0.063
Advice Density	.200	.077	2.60*			
AdvBYCom	-.011	.083	-0.132			
ComXAC	-.573	.145	-3.95*			
Hin Density				.102	.082	1.25
HinBYCom				.124	.085	1.46
ComXHC				.319	.130	2.46*
00-ComXAC	.566	.207	2.74*			
10-ComXAC	.343	.249	1.38			
11-ComXAC	.770	.151	5.10*			
00-ComXHC				-.176	.143	-1.23
10-ComXHC				-.196	.224	-0.877
01-ComXHC				-.237	.210	-1.13

Note: Parameters significant at $p < .05$ are indicated with an asterisk (*) and parameters significant at $p < .10$ are indicated with a cross (†). Manip = Manipulation, Com = Communication, Hin = Hindrance, AdvBYCom = Advice-Communication QAP Correlation, HinBYCom = Hindrance-Communication QAP Correlation, ComXAC = Cross-product of Communication Density and Advice-Communication QAP Correlation, ComXHC = Cross-Product of Communication Density and Hindrance-Communication QAP Correlation.

Table 23: Multiple regression analyses of MTS performance on inter-team process and structural alignment

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
			AC > 0	AC < 0	HC > 0	HC < 0
	(N = 75)	(N = 75)	(N = 49)	(N = 25)	(N = 35)	(N = 39)
Step 1						
Manip 1	.185	.185	.069	.475*	.395*	-.003
Manip 2	-.128	-.128	-.165	.114	-.061	-.174
Manip 3	.068	.068	.027	.285	-.310	.331*
Mission	-.079	-.079	-.158	.034	.073	-.134
R^2	.059	.059	.052	.340	.244	.170
F	1.10	1.10	0.601	2.581†	2.421*	1.741*
Step 2						
Com Density	.418*	.402*	.471*	.390*	.240	.408*
Advice Density	-.075					
AdvBYCom	.175					
Hin Density		-.080				
HinBYCom		.012				
ΔR^2	.186	.159	.218	.142	.053	.146
ΔF	5.51*	4.46*	12.83*	5.22*	2.200	7.019*
Step 3						
ComXAC	.330*					
ComXHC		.011				
ΔR^2	.058	.000				
ΔF	5.44*	.008				

Note: Parameters significant at $p < .05$ are indicated with an asterisk (*). Manip = Manipulation, Com = Communication, Hin = Hindrance, AdvBYCom = Advice-Communication QAP Correlation, HinBYCom = Hindrance-Communication QAP Correlation, ComXAC = Cross-Product of Communication Density and Advice-Communication QAP Correlation, ComXHC = Cross-Product of Communication Density and Hindrance-Communication QAP Correlation,

Table 24: Multiple regression analyses of MTS performance on inter-team process and structural alignment sub-grouped by manipulation condition

	Model 1 M=00 (N=19)	Model 2 M=00 (N=19)	Model 3 M=10 (N=15)	Model 4 M=10 (N=15)	Model 5 M=01 (N=22)	Model 6 M=01 (N=21)	Model 7 M=11 (N=19)	Model 8 M=11 (N=19)
Step 1								
Manip 3	.225	.225	-.072	-.072	.215	.260	-.110	-.110
Mission	-.409†	-.409†	.315	.315	-.312	-.352	.079	.079
R^2	.210	.210	.095	.095	.143	.183	.019	.019
F	2.122	2.122	0.632	0.632	1.589	2.018	0.158	0.158
Step 2								
Com Density	.507*	.443†	.400	.468	.245	.244	.738*	.554*
Advice Density	-.032		-.279		-.187		-.207	
AdvBYCom	.255		.244		.051		-.367	
Hin Density		-.180		-.134		-.138		-.079
HinBYCom		-.140		.305		.058		-.049
ΔR^2	.247	.237	.294	.267	.117	.085	.478	.286
ΔF	1.973	1.857	1.444	1.254	0.845	0.577	4.129*	1.780
Step 3								
ComXAC	.300		.441		.885†		.016	
ComXHC		-.766*		.478		.451		-.329
ΔR^2	.061	.163	.038	.041	.136	.113	.000	.077
ΔF	1.525	5.030*	0.530	0.548	3.386†	2.558	0.004	1.489

Note: Parameters significant at $p < .05$ are indicated with an asterisk (*). Manip = Manipulation, Com = Communication, Hin = Hindrance, AdvBYCom = Advice-Communication QAP Correlation, HinBYCom = Hindrance-Communication QAP Correlation, ComXAC = Cross-Product of Communication Density and Advice-Communication QAP Correlation, ComXHC = Cross-Product of Communication Density and Hindrance-Communication QAP Correlation.

Table 25: Multiple regression analyses of MTS performance on inter-team process and structural alignment moderation comparing for differential effects across manipulation conditions

	Model 1 (N = 75)	Model 2 (N = 74)
Step 1		
Manip 1	.185	.180
Manip 2	-.128	-.123
Manip 3	.068	.073
Mission	-.079	-.084
R^2	.059	.058
F	1.096	1.054
Step 2		
Com Density	.403*	.397*
Advice Density	-.170	
AdvBYCom	.155	
Hin Density		-.129
HinBYCom		.011
ΔR^2	.209	.169
ΔF	6.361*	4.800*
Step 3		
ComXAC	.323*	
ComXHC		.003
ΔR^2	.057	.000
ΔF	5.556*	0.000
Step 4		
00-ComXAC	.147	
10-ComXAC	.070	
01-ComXAC	.373	
10-ComXHC		.328†
01-ComXHC		.426*
11-ComXHC		-.039
ΔR^2	.027	.086
ΔF	0.889	2.574†

Note: Parameters significant at $p < .05$ are indicated with an asterisk (*). Manip = Manipulation, Com = Communication, Hin = Hindrance, AdvBYCom = Advice-Communication QAP Correlation, HinBYCom = Hindrance-Communication QAP Correlation, ComXAC = Cross-Product of Communication Density and Advice-Communication QAP Correlation, ComXHC = Cross-Product of Communication Density and Hindrance-Communication QAP Correlation.

CHATPER 4

DISCUSSION

Previous research on both teams and multiteam systems has captured relevant processes and states largely focused on their emergence to the collective level trough compositional processes (Kozlowski & Klein, 2000). That is, these phenomena are most commonly theorized and studied to exist as singular characteristics of the team which arise through shared perspectives and experiences. The goal of this thesis was to continue expanding beyond this well established compositional perspective and better capture these collectives as they truly exist: a system of individuals interacting with one another. From this perspective, the nature of interpersonal interactions and perceptions is not expected to exist uniformly across the levels of the system nor can higher-level phenomena be captured solely as aggregations of lower-level phenomena. Accounting for compilational mechanisms of emergence is expected to more accurately capture the complex nature of both team and MTS phenomena (Kozlowski & Klein, 2000; Crawford & LePine, 2013).

This thesis used sociometric measurement and network analytic techniques in an attempt to capture phenomena established in teams research (i.e., communication, collective cognition, and affect) as they exist at the collective level through compilational, rather than traditional compositional, emergence. While traditional psychometric measures of collective (team or MTS) phenomena are designed to capture phenomena as they exist abstractly at the higher-level of analysis, the sociometric measures utilized capture analogous phenomena as it exists between every pair of individuals. This measurement technique implicitly assumes that the pattern of interactions between each individual dyad holds substantive importance in understanding how phenomena emerge and impact outcomes at higher levels of analysis.

While these measures must ultimately be aggregated to the appropriate level of analysis, this can be done in ways that maintain meaningful differences in how phenomena are structured throughout the collective. These structural differences were expected to impact the relationship between communication and system performance to the extent that dyadic-level interpersonal relationships when aligned with one another across behaviors and cognitive and affective states. The established expectation is that collective states existing monolithically throughout the collective and thus uniformly moderating the effects of behaviors as they exist solely at the collective level (Mathieu, et al., 2008). In this perspective, however, both states and behaviors are expected to vary throughout the collective and moderation at the collective level exists due to the overall pattern of these dyadic relationships.

The results of this thesis demonstrate the theoretically meaningful relationships that emerge, and thus are best captured, compilationally within teams and MTSs. This was done utilizing a sample of 75 independent simulated multiteam systems each composed of six members structured into two, three-person teams collected as part of a larger (in focus) laboratory experiment. The direct and conditional effects of the phenomena of interest on team and MTS performance were tested using network analytic indices which are expected to capture collective phenomena in a manner more similar to how they actually manifest (Kozlowski & Klein, 2000; Borgatti & Foster, 2003; Crawford & LePine, 2013).

Direct Effects of Process and Emergent States in Teams and MTSs

A total of five hypotheses, each consisting of a specific expected relationship at both the team and MTS levels of analysis, were tested in this thesis. Unfortunately, none of the hypotheses obtained full support from the conducted analyses. However, several did obtain support at either the team- or MTS-level. Hypothesis one, that the density of communication relationships would positively impact performance, was supported at the MTS-level. The lack of support found for this hypothesis at the team level is not surprising given the subsequent result found for hypothesis five which found a significant moderator of the relationship between intra-team communication and team performance. The pattern of the moderated relationship indicates a change in direction, rather than strength, of this relationship resulting in the non-significant (essentially zero) main effect. It is clear that the strength of this moderator was greater than expected. Further investigation of this pattern of results will be discussed in the context of hypothesis five.

Hypothesis two, that the density of advice relationships would positively impact performance, was supported at the team-level. It is important to note, that a marginally significant ($p < .10$) relationship with performance was found to exist at the MTS-level, but this relationship was opposite the predicted direction. It was found that, rather than being beneficial to MTS performance, the density of advice relationships between members of different teams was negatively related to MTS performance. This is a counterintuitive result as the density of advice relationships was expected to measure the strength and quality of the collective cognitive structure which has shown consistent positive relationships with performance (DeChurch & Mesmer-Magnus, 2010). Therefore, the first consideration may be that measuring dyadic advice relationships does not appropriately tap collective cognition. Conversely, it may not be the case that these relationships themselves fail to tap collective cognition, but rather that the calculated density index does not capture the quality or functionality of the cognitive structure at the MTS level. This is evidenced from the significant positive relationship observed for the same advice relationships and calculated index at the team level of analysis.

The value of the density index increases to the extent that relationships are observed to be both more prevalent and of higher intensity. Thus, when used to measure collective cognition, there is an implicit assumption that the quality of collective cognition is maximized when all members have strong advice relationships with all others. In the context of multiteam systems versus teams, it is less likely that such a cognitive structure will be maximally effect as redundancy of knowledge and variance in interdependence suggests the presence of unnecessary relationships (Salas, Burke, & Cannon-Bowers, 2000). That is, as a collective's size and complexity increases, seeking information from every other person is less efficacious. Rather, collective cognition is most functional when people know from whom they need information (i.e., transactive memory; Lewis, 2003) and when this meta-knowledge is shared (i.e., shared mental models; Mathieu, et al., 2000; Lim & Klein, 2006).

These conditions are not well captured by the density index used and thus may be driving the nonsignificance of this relationship. Support for this post hoc explanation may be seen in the significant moderation of the effects of communication on performance by the alignment of behavioral and cognitive structures found in hypothesis four. This structural alignment may be a reasonable analogue for the aforementioned transactive memory and shared mental model conceptualizations of cognition. Specifically, structural alignment of these phenomena elucidates the importance of the cognitive mediation of behavior's effect on performance (Cohen & Bailey, 1997; Marks, et al, 2001; DeChurch & Mesmer-Magnus, 2010). That is, when the pattern of behaviors is aligned with collective cognitive structure, these same behaviors are more beneficial to collective performance. These results suggest that accounting for neither cognition nor behavior in isolation appropriately captures the effects of collective phenomena on performance, but rather accounting for the compound effect of the two is essential. These results will be discussed further in the context of hypothesis four.

Hypothesis three, that the density of hindrance relationships would negatively impact performance, was supported at neither the team- nor MTS-level. It was expected that higher density of hindrance relationships, capturing the presence of negative affective state, would lead to poorer performance at both levels. The lack of a significant relationship with performance may be due to several factors, the first of which may simply be that hindrance relationships do not appropriately capture negative affective states within teams or multiteam systems. However, the impact of hindrance relationships in other settings has been well established and consistently negative effects have been found (Contractor & Monge, 2003). Thus, it is unlikely that these relationships fail to capture some form of negative affect within the collective. Rather, the specific types of interactions that must occur for appropriate team or MTS functioning may be different than those observed in other context within which these relationships have been studied.

Primarily, it may be that the nature of interdependence within teams and MTSs results in hindrance arising through different interactions or perceptions when compared to other collectives. High levels of interdependence force individuals to more frequently and less efficiently choose tradeoffs between completing taskwork and teamwork (Crawford & LePine, 2013). With this, those that are perceived to have some essential resource (e.g., information) may immediately be perceived as hindering as their task and interpersonal demands simply do not allow for as much teamwork as would be considered acceptable. This potential explanation can be seen from the results in Tables 3 and 4 which show the presence of significant correlations between both the communication, advice, and hindrance densities as well as significant alignment of advice and hindrance structures at both the team- and MTS-levels. These results indicate that advice and hindrance relationships often coexisted. That is, individuals were more likely to perceive hindrance arising from those others perceived to provide them with advice. This certainly muddies the interpretation of the nature of these hindrance relationships, but supports the existence of behavioral trade-offs over the presence of truly dysfunctional or negative affective relationships between individuals.

Secondly, it may be that the hindrance relationships do indeed capture negative affect but that said only has an impact on performance to the extent that individuals respond with either functional or dysfunctional behaviors. That is, rather than the existence of hindrance relationships themselves being detrimental to performance, the manner in which hindrance is dealt by the collective impacts performance. As aforementioned, such relationships can impact both the focus (towards or away; Davis, 1963) and content (functional or dysfunctional; Staw & Kramer, 2003) of behaviors. As was theorized within hypothesis five, it is expected that individuals would prefer to direct behavior away from hindering individuals and that behaviors focused towards said would largely be dysfunctional. The observed pattern of results supports an effect of hindrance relationships on interpersonal behavior that supports this explanation, but not in the manner hypothesized. These results will be discussed further in the context of the final hypothesis.

Moderated Effects of Process and Emergent States in Teams and MTSs

Hypothesis four, that the strength of the positive impact of communication relationship density on performance is moderated by the structural alignment of the communication and advice relationships, was supported at the MTS-level but not the team level. The significant finding at the MTS-level may yield a substantial contribution to the understanding of both behavior and cognition in this context. As aforementioned, this finding along with the counter-intuitive finding of advice density being negatively related to performance at the MTS level provide insight to understanding the effects of shared cognition in collectives. The analyses within hypothesis two found a marginally significant main effect of advice density on performance while hypothesis four found a significant positive interaction of the relationship between communication and performance due to advice-communication structural alignment. It is important to also note that no significant main effect of structural alignment between communication and advice relationships on performance was found. Together, these results yield important conclusions regarding the effects of both behavior and collective cognition in MTSs.

First, these phenomena clearly exist in a complex environment wherein neither compositional nor even compilational representations alone capture the nature of their effects on each other or outcomes. Beyond the measurement method itself, the lack of a significant effect of communication and cognitive structural alignment on performance indicates that simply capturing the extent to which the behaviors and cognitions co-occur is not enough to predict subsequent performance. Previous research (e.g., Klimoski & Mohammed, 1994; Salas, et al., 2000; Fiore & Salas, 2004) has implicitly stressed the importance of this structural alignment and, though no direct effect may exist, it does appear to be a necessary precondition for effective team process. The significant moderation of the effect of communication on performance by advice-communication alignment indicates that communication at the MTS level is most beneficial when individuals consider communication recipients based on their informational value. This suggests that, while an established cognitive representation of knowledge within the collective is important, performance is most benefitted when there exists appropriate coordination between the enacted behaviors and the cognitive structure itself. These results appear to support the need for an established transactive memory system as conceptualized by Lewis (2003) which requires both knowledge of where information lies and behavioral coordination allowing for the retrieval of said information.

Conversely, the lack of significant result at the team-level has several possible explanations, of which, one methodological and one substantive possibility will be discussed. First, the small team size greatly restricts the amount of variation possible in the patterns of relationships as three persons allows for only six relationships while patterns consisted of 18 relationships at the MTS level. Though this may have been a contributing factor, it is unlikely to have fully attenuated any possible significant interactive effect for two reasons. First, preliminary analyses showed a wide (though non-normal) distribution of the QAP correlations for both teams encompassing values between -.88 & .99 and -.65 and 1.00, respectively. Second, the analogous team-level analysis for hypothesis five was found to be significant undermining the methodological limitations due to restrictions of variance in the observable structures. This indicates that the lack of significant findings for this hypothesis may have a substantive meaning.

Unlike the analogous relationship at the MTS-level, the strength of advice relationships at the team level had a significant positive impact on performance (though the main effect of communication and advice structural alignment were both non-significant). Together these findings seem to indicate that, contrary to what was found for inter-team phenomena, the relational structures of phenomena within teams are less impactful than the overall intensity of certain phenomena (possibly due to the smaller size or lower complexity; Kozlowski & Klein, 2000; Marks, et al., 2005). Thus, it was found simply that teams with higher advice density, which was expected to capture higher quality collective cognition, perform better than those with lower levels. This effect appears to exist irrespective of the amount of behavioral process or the degree of structural alignment existing between behavioral and cognitive relationships. Given the invariant nature of the teams in terms of their structural and contextual characteristics, it is impossible to determine the extent to which this result may generalize across differing levels of information accessibility or redundancy and interdependence.

Hypothesis five, that the impact of communication relationship density on performance will be moderated by the structural alignment of the communication and hindrance relationships, was supported at neither the team- nor MTS-level. In addition to the lack of the hypothesized main effect of the hindrance relationship density and the non-hypothesized main effect of hindrance-communication structural alignment on MTS performance, no significant interaction effect was found at the MTS-level. The most likely reason for this lack of finding is the unexpectedly high correlation between the

MTS and team hindrance relationship densities which were found to be strongly related across levels (r = .562 and .629, respectively). However, no significant correlation in the hindrance relationship densities existed between the two intra-team measures (r = .079). Thus, the two intra-team hindrance relationship densities explained 66% of the variance in inter-team hindrance relationship density. Recall that individuals rated every other individual separatedly and each of the three densities (the two intra-team measures and the single inter-team measure) were calculated using mutually exclusive subsets of those dyadic ratings. It is important to note that similar (though weaker) relationships exist across levels between the measures of advice relationships (r = .481 and .238, respectively), but the amount of measured variance of MTS-level advice relationship strength attributable to team-level relationships is much lower (r^2 = .26).

The strength of these relationships were unexpected as, though the teams existed within the higher-level MTS environment, there is no implicit reason as to why the existence of dyadic hindrance relationships occurring at one level should directly, consistently, or systematically influence those at another (Kozlowski & Klein, 2000). The fulfillment of this expectation can be plainly seen in the lack of a significant relationship between the hindrance densities for each team which. That is, the amount of hindrance reported within one team had no effect on the amount of hindrance reported within the other team. It is possible that the level of hindrance being experienced in at least one team substantially impacts the amount of hindrance within the entire MTS.

However, the simpler mechanism is that participants were simply unable to accurately assess the level of hindrance occurring at the MTS level. That is, when high levels of hindrance exist within a team, similarly high levels are perceived to exist in the system. This may be due to affective contagion mechanisms substantively impacting the actual intensity of negative affect within the system directly. Applying theorized team process mechanisms related to boundary management (Marrone, 2010) and backup behaviors (Zaccaro, et al., 2000) may more clearly explain this pattern of results. Specifically, when hindrance at one level was perceived to be high, individuals relied more greatly on those members at the opposing level of the system. For example, when hindrance is high within a team, those members may attempt to utilize inter-team relationships as an alternative source of resources or coordination that is only available within the team. The resulting inability for those others to provide these necessities will foster false perceptions of hindrance that would not have existed without the initial influence of hindrance within the team.

Irrespective of the possible measurement issues occurring for relationships at the MTS-level, no evidence exists suggesting similar confounding effects at the team-level. A significant interaction effect was found at the team level, but the observed relationship was opposite that which was predicted such that structural alignment lead to a positive relationship while contra-alignment lead to a negative relationship. The converse was hypothesized due to expected negative changes in the content, tone, and interpretation of communications occurring between individuals with the dysfunctional affective relationships expected when hindrance is high. The observed relationship, however, indicates that such a process did not occur or that, if such a process did occur, it did not meaningfully impact performance. Rather, this pattern of relationships seems to indicate that balance mechanisms remained the dominant factor in explaining the efficacy of communication. This supports the erroneously dismissed impact of individuals who tended to increase attention towards those who were associated with hindrance. As was discussed earlier, structural alignment with a negative state indicates a perception of process as being dysfunctional when the receiver of the process is not associated with the negative affective state. The expectation and positive impact of such perceptions is reasonable in team contexts as it aligns with such considerations as conflict management (DeChurch, Mesmer-Magnus, & Doty, 2013), the potentially negative effects of autonomy (Langfred, 2004), and the importance of back-up behaviors within teams (LePine, et al., 2008).

Differential Effects of Process and Alignment across Manipulation Conditions

A major consideration when interpreting the results presented in this thesis must be discussed due to the potential effects on the relationships of interest. The relationships of interest in this thesis were not expected to be related to the different conditions of the manipulations which were included to test a different set of hypotheses core to the development and administration of the laboratory study from which this data was derived. Manipulation 1 had two conditions that determined whether participants were trained to use leadership language that supported within or between team coordination. Manipulation 2 also had two conditions and determined whether participants were instructed on the goals of their teams and the MTS using language focused at the teams individually or the MTS as a whole. While it may be reasonably expected that the different conditions would impact the observed intensity of the processes and even their alignment, there was no a priori expectation that the observed relationships with performance would change.

This assumption, however, was not supported as the effects of several relationships between processes and performance were found to be moderated by at least one of the four possible manipulation conditions. At the team level, a pattern exists such that the expected benefit of greater amounts of communication and the moderation of this relationship due to advice-communication alignment is impacted by the congruence between the conditions of the two manipulations. When there is congruence (Tables 6 & 9), communication is negatively related to performance and when there is incongruence (Tables 7 & 8), communication is positively related to performance. In all conditions, increased advice-communication alignment weakens the observed relationship between communication and performance. Additionally, hindrance was found to be negatively related to performance when the teams were exposed to their goal information at the team level and positively related to performance when the teams' goals were presented from an MTS perspective.

At the MTS level, the moderation of the effect of communication on performance due to hindrance-communication alignment was impacted by the congruence between the two manipulations. When there is congruence (Tables 18 & 21), the positive relationship between communication and performance is weakened by hindrance-communication alignment. Conversely, when there is incongruence (Tables 19 & 20), the positive relationship between communication and performance is strengthened by hindrance-communication alignment.

It is important to note that, though there are numerical and valence differences in the effects of these processes across the manipulation conditions, very few were found to be significant at the .05-level at both levels of analysis (Tables 10, 16, 22 & 25). Despite this, it is still possible that these differences are meaningful as the sample size within each condition is relatively small and the manipulations themselves were not intended to elucidate such effects. The overall pattern appears to indicate that teams exposed to leadership behaviors and goal information at the same level perform better on their own goals to the extent that they engage in implicit coordination (i.e., utilize less communication). Conversely, teams with incongruence between leadership behaviors and goal information perform better on their own goals to the extent that they engage in explicit coordination (i.e., utilize more communication).

A similar mechanism explaining the pattern of relationships observed at the team level may also be driving the effects observed at the MTS level. As aforementioned, congruence between the conditions of the two manipulations may support the environment to prefer implicit coordination while incongruence may benefit the use of explicit coordination. Though this effect was not strongly observed in the direct relationship between communication and MTS performance, it may be driving the moderation of this relationship due to hindrance-communication alignment. Implicit coordination is beneficial when the collective has relatively complex understanding of the tasks, goals, and information distributed across all members (Rico, et al., 2008). Thus, in the circumstance that implicit coordination is not effective (i.e., when there is incongruence between the manipulations), the system benefits from improving the distribution of this knowledge.

Considering the aforementioned possibility of hindrance relationships being indicative of informational rather than interpersonal detriments, hindrance-communication alignment may indicate the extent to which individuals communicate with those that lack information. Therefore, in the circumstance that the system does not yet have a requisite distribution of knowledge across individuals (i.e., when there is incongruence), greater communication with those others that lack information improves performance. Conversely, in the circumstance that the system has a requisite distribution of knowledge (i.e., when there is congruence), greater communication with those others that lack information does not improve performance. That is, in the first case communication is more likely to make necessary knowledge available to the system while, in the latter case, communication is more likely to be sharing redundant or unnecessary information.

Beyond the effects due to congruence at both levels, the differential effects of hindrance on performance across manipulation conditions appear to be driven by another mechanism. These differential relationships are driven by whether teams received information about their goals at the team rather than the MTS level. This appears to indicate that the nature of the perception of hindrance differs due to the level of focus at which team and system level goals are presented. That is, hindrance appears to capture the perceptions of dysfunctional tension when goals are focused at the team level. Conversely, hindrance appears to capture the perceptions of functional tension when goals are focused at the MTS level. The pattern of these relationships may be analogous to the expected differential impact of task and relational conflict (Jehn & Mannix, 2001). Given that this pattern of relationships exist entirely at the team level, team-level focused explanation of goals are congruent with the goals of interest which will likely improve task and role clarity. Therefore, hindrance is less likely to exist due to informational and more likely due to interpersonal issues which supports the observed negative effects analogous to the expected effects of relational conflict. Conversely, MTS-level focused goal knowledge is incongruent with the goals of interest and will detriment task and role clarity. In this case, hindrance is more likely due to informational rather than interpersonal issues which supports the observed positive effects analogous to the expected effects of task conflict.

Implications for Theory and Practice

The primary contribution of this thesis is the examination of the differential and compound roles of communication, advice, and hindrance relationships predicting team and MTS performance. Little work has been done on understanding the impact of the emergent structure of these phenomena on the effects of one another and, subsequently, their impact on performance. Additionally, a greater focus on these conditional effects of team and MTS processes will account for greater understanding of potentially unintended consequences of the occurrence of behaviors in the presence of certain intensities or structures of cognitive and affective states. By taking a compilational or network perspective, this study allowed for the assessment of the unique effects of behavioral process based on the degree to which it is structurally aligned with the underlying team and MTS environment. As behavioral process is expected to be impacted by the affective and cognitive states within which it occurs, capturing the structural characteristics of said is essential in accurately assessing the impact of these states, behaviors, and the co-occurrence of these phenomena on performance.

Making specific prescriptive statements on either team or MTS functioning cannot be done until there is more comprehensive understanding of the role of the interdependencies inherent to these collectives. This research acts as a necessary stepping stone in comparing and contrasting the manner in which emergent states and processes may affect performance at these two important levels of analysis. As these results have indicated, states desirable at the team level are not necessarily desirable and may even be detrimental at the MTS level (e.g., strong overall perception of collective cognition). Therefore, treating an MTS as if it were simply a large team and over-applying team-level findings will likely yield less effective systems. Rather, MTSs must be organized and lead as unique organizational units accounting for their multilevel nature and complexity. Further, processes, such as communication, which are commonly shown to be positively related to performance in most collective work arrangements may not be universally functional than expected. The effect of communication at both the team and MTS levels was found to vary greatly due to the specific internal states present within the collective. This variance can be so extreme as to potentially make a process that is generally considered to be functional ineffective or even dysfunctional.

Limitations

The most significant limitation of this study is attributable to the specific characteristics arising from its data collection consisting of a single session laboratory-based study. The teams and MTSs in this sample were only together for a short period of time (approximately 5 hours) and had no prior history or shared future outcomes beyond that of simply completing the study itself. Though such a paradigm is common in the research of collective phenomena, it is important to note how such a context may limit the external validity of the results. The lack of prior history and short lifetime of the system may have resulted in too little interaction between participants for fully realized cognitive and affective states to emerge at either or both levels. Though there was wide variance in the reporting of such states across the independent sessions, it is unknown to what extent these states would have been similar were they given a longer timeframe in order to develop their shared environment. That is, different collectives will progress through the developmental phase at different due to their basic compositional characteristics (Futoran, Kelly, & McGrath, 1989) as well as, potentially, the different conditions of the manipulations. Depending on the developmental phase that a given collective is in, both characteristics and the effectiveness of the emergent states and processes themselves are likely to be vary greatly. Additionally, because collectives knew that their interactions with one another would be limited to this setting and fostered relationships would likely have little value over the long-term, the behaviors and subsequent reactions to such behaviors may be different to what would be expected in a non-laboratory setting.

Another limitation to note is regarding the measurement of the phenomena of interest. First, sociometric measures are most commonly single-item scales and thus cannot be validated for internal consistency using traditional psychometrics. With this, it is difficult to say to what extent the measures of advice and hindrance accurately captured the actual relationships existing between individuals. Additionally, though these are established and common items used in network science, there is no known data which directly validates their use as a sociometric measure of collective cognition or affect, respectively. Thus, it is possible that though these measures were shown to have both main and conditional effects on performance, the mechanisms driving the observed relationships may not be consistent with the cognitive or affective bases argued herein. Lastly, communication was collected through trace data of the amount of time communication channels between each participant were open which minimized any concern in the validity of this network measure accurately capturing communication behavior. However, such a measure is entirely lacking in content and thus requires many assumptions regarding the quality, tone, informational value, and other important aspects of the behavior itself. With this, it is impossible to differentiate a large of amount of communication that was entirely off topic and the same amount of communication fully focused on sharing information, providing leadership, or engaging in any other functional team process. With this, both the direct and conditional relationships observed may change depending on the nature of the observed communication whether or not the total amount of communication is consistent.

Future Research

There are two important next steps in progressing the understanding of teams and multiteam systems from the perspective of network science. First, though the research conducted in this thesis examined the effects of relationships at two levels of analysis, all substantive analyses concerned only single-level relationships (HLM was only used to control for the effects of non-independence of the two teams within each independent MTS). The overall pattern of these findings (e.g., opposite effects of advice strength at the two levels, generally inconsistent effects of analogous constructs between levels) continues to elucidate the validity of the arguments made by MTS theory that simply studying team-level process and applying these findings in more complex collectives is not an appropriate strategy to understanding or improving process and performance (e.g., Marks, et al, 2001; DeChurch & Zaccaro, 2010). As aforementioned, these findings suggest differences in the mechanisms of states and processes at these two levels but fail to directly explore the impact of these phenomena at one level on process and performance at another level. For instance, strong intra-team advice relationships lead to better team performance while strong inter-team advice relationships lead to worse MTS performance; will the analogous cross-level relationships follow a similar pattern? This is not an answer that can be simply assumed or deduced from the current findings.

The second next step is more general in regards to the application of sociometric measurement and the network perspective in conceptualizing, measuring, and interpreting these phenomena. As aforementioned, the current level of understanding of both the internal consistency and construct validity of these measures are a major concern in the theoretical interpretation of findings. Additionally, there are myriad network indices beyond the density and QAP correlations utilized here that may be calculated for any given set of relationships which yields even more complex validity concerns.

With this, the current problem is twofold. First, substantively relating the constructs captured by sociometric measures with traditionally validated psychometric measures is important to ensure accurate understanding of what is actually being studied. Second, theoretical work in the conceptualization of the meaning and appropriate interpretation of different indices across phenomena is necessary for consistency in examining the effect of these patterns. Similar work has been conducted with the comparatively simpler aggregation of psychometric data between individuals and has yielded important understanding in the meaning of both different aggregations (Kozlowski & Klein, 2000) and variance calculations (Harrison & Klein, 2007). With additional work in these two lines, more theoretically meaningful and potentially impactful relationships can be explored in both MTS and more general organizational behavior research lines.

Conclusion

This thesis sought to provide evidence in order to answer the questions: 1) how do the compound effects of collective emergent states and processes impact performance and 2) are there differences in the pattern of these relationships across the team and MTS levels of analysis? Using the network perspective to conceptualize the emergence of team phenomena through both compositional and compilational processes, new understanding of the interdependence of these phenomena was found. The relatively novel conceptualization and measurement of behavioral process, cognitive states, and affective states as dyadic interpersonal relationships allowed the nature of these phenomena to be more thoroughly explored. The unique measurement and analytic approach utilized allows assessment of both the conditional relationships of compositionally emergent phenomena and the compilationally emergent structural alignment across phenomena at both the team and MTS levels. Overall, these states and processes were found to have both direct and conditional effects on performance at both levels of analysis.

These findings indicate that accounting for the compilational emergence of such phenomena is an important consideration in understanding both team and MTS functioning even after capturing global states and processes. Additionally, the pattern of results provides further evidence that the impact of neither compositionally nor compilationally emergent phenomena can be assumed to be homologous across the levels within a multiteam system. Beyond the substantive findings, these results indicate a rich area of future research using network science. Collective phenomena must be conceptualized and captured through a multilevel and compilational lens for the science to meet the increasing sophistication of such organizational units.

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